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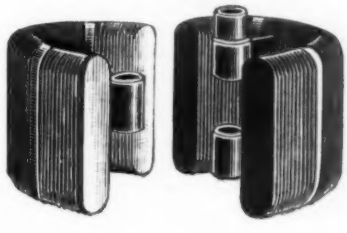
CENTRAL STATION ELECTRIC LIGHTING.

AN instance of what may be accomplished by perseverance of the steady, plodding sort, is to be witnessed in that retreat beloved by all weary Cockneys who seek relief from the whirl and bustle of business in the excitements born of pleasure—gay and giddy Brighton. For more than four years past a small station supplying electric current for purposes of illumination to the adjoining houses has been in operation in the Gloucester Road, and though the amount of success obtained has not been abnormal, the results have yet been far from discouraging. The area of supply is at present limited only by the extent of the demand; that is to say, there is sufficient plant at the central station to permit of a much larger supply of current than is at present called for, although the managing director, Mr. Arthur Wright, is not without hopes that he will soon succeed in persuading a greater number of the inhabitants that it is to their interest to adopt the newer and purer light. The engine supplying motive power is capable of running 3,000 incandescent lights, but it is calculated that there would be no difficulty in lighting houses wired for 6,000 lamps, as it rarely or never happens that more than half the lights are in use at one time. A second engine and boiler are kept in reserve, and always in readiness, so that, in the event of the first engine breaking down, the lighting would not be interrupted. Mr. Wright is perhaps not quite so much alive as he should be to the importance of secondary batteries in securing absolute immunity from even a momentary interruption of the lighting; but for this he may be well excused in face of the fact that for four years no stoppage of the engine occurred; at the end of the period named, in October last, a new engine was started, and one of the pump valves gave way, necessitating a stoppage for repairs. The principal consumer of current on the circuit is the Brighton and South Coast Railway Company's terminus, but private houses, shops, offices, and hotels are also lighted from the same centre, and it is not the least interesting or important feature of this station that the charges are based upon the records of electric meters, the working of which is said to be extremely satisfactory. We shall anxiously watch for information upon this point, for if it be proved here that meters are absolutely trustworthy, a very vexed question will be set at rest. We are glad to think that even so small a measure of success has attended the efforts of the Brighton Electric Light Company, and trust that publicity will lead other towns to emulate the example of the fashionable watering place.

DIEHL'S GRAMME ARMATURE.

ONE of the great objections to the employment of the Gramme type of armature in small motors, says the *Electrical World*, heretofore consisted in the fact that it was impracticable to wind them on account of the small interior space within the ring.

In order to overcome this objection, Mr. Ph. Diehl has designed a form which permits of easy winding. He accomplishes this end by dividing the armature into two parts. This is shown in the accompanying



illustration, which exhibits the armature taken apart. As will be seen, it consists of two half-rings, of which one has a single, and the other a double eye attached to a spoke in each half-ring. In other words, the arrangement is exactly like that of a door hinge.

The half-rings are separately wound with wire, which can be very conveniently done, and then, being pressed together, the eyes come in line; and the shaft being passed through, like the pin in a door hinge, the whole is firmly bound together.

THE LAY TORPEDO.

ON Saturday last the Lay Torpedo Company arranged for a series of demonstrations of this torpedo to take place in the estuary of the Colne. The party assembled on board the guardship at Brightlingsea, and included Lord Charles Beresford; Viscount Pollington; Lieut.-Col. Armstrong, R.E., Inspector of Submarine Defences; Major McKinlay, R.A.; Captain G. S. Clarke, R.E., representing the Inspector-General of Fortifications; Captain Drury, R.N.; Captain Schrœder, of the Imperial German Navy, and other military and naval representatives. The peculiarity of the Lay torpedo is its electrically-controlled steering apparatus, and it was for the purpose of showing how readily it could be started, steered, and stopped, that this trial was arranged. As far back as 1882 experiments were made with a torpedo on this system in the Bosphorus, when the correspondent of the *Times* thus summed up the results:—"It was conclusively shown that the Lay torpedo can be successfully manipulated in any waters under any circumstances of wind or sea; that the steering apparatus is so perfect that neither the strongest currents nor the heaviest sea can prevent the torpedo reaching the object at which it is directed; that the cable it carries and 'pays out' as it proceeds ahead does not hamper its movements in the slightest degree, and that the loss of its length, due to the pressure of currents or any unusual depth of the water, is very small indeed; that its range is only limited by the power of the glasses used by the operator, and may be safely set down to one and a-half miles."

Hobart Pasha, writing on the subject at the time, remarked that while the trials showed the Lay torpedo to be perfect in its accuracy of steering and facility of manœuvring in strong currents, he and other critics were convinced that the speed then attained, namely, nine knots an hour, was not sufficient. During the last four years the construction has been improved, and the speed is said to have been increased to 12½ knots and upwards. Unfortunately, the demonstration on Saturday came to a premature termination, owing, it was explained, to some seaweed accumulating about the

propeller and causing short-circuiting, so that the steering apparatus became inoperative. The torpedo was launched and ran a distance of about 200 yards, but it was soon seen that something was wrong; instead of gliding along invisibly under the water as it should do, it careened over somewhat, and so caused the blades of the screw to produce a foam showing the track of the weapon. It was then found that the steering gear did not come into play, and the operations were suspended.

As, however, further trials are to come off shortly, the following details of this formidable weapon of warfare may be of interest. The Lay torpedo is constructed of brass, and is 21 feet in length, with a diameter of 18 inches. It is cigar-shaped, the nose being pointed and the stern flat, with two small rudders attached. Three feet from the nose is a two-bladed screw-propellor, which is driven by a Tower spherical engine worked by carbonic acid gas, which is compressed into a steel cylinder having a capacity of seven cubic feet, contained within the casing of the torpedo. These charged cylinders can be stored for almost any length of time, and the machinery for charging is simply an iron retort, the pressure of the gas given off being sufficient to compress it into a liquid state. The torpedo can be exploded either electrically or by contact, the charge being 150 lbs. of the new German explosive, roburite, which is calculated to be sufficient to blow any iron-clad out of the water. When started on its journey, either from the shore or from a boat, the electrical wire is paid out from the stern, thus maintaining connection with the battery and keyboard to be manipulated at the starting point. The wire is of the lightest description, and is carried off the drum by the mere friction of the water as the torpedo rushes through it.

PRACTICAL NOTES CONCERNING THE CONSTRUCTION, USE AND MANAGEMENT OF STORAGE BATTERIES.

By A. RECKENZAUN.

(*Continued from page* 99.)

Graphic Representations.—In order to appreciate fully the internal working of a secondary battery, it is best to construct curves; there we can see at a glance the variations which take place in the course of an experiment. Such curves for secondary batteries are as useful and as instructive as the indicator diagrams of a steam engine. Figs. 1, 2 and 3 are taken from Tables I. and II. (page 609, Vol. 18.) For the abscissæ in each we take the time in hours, and for the ordinates

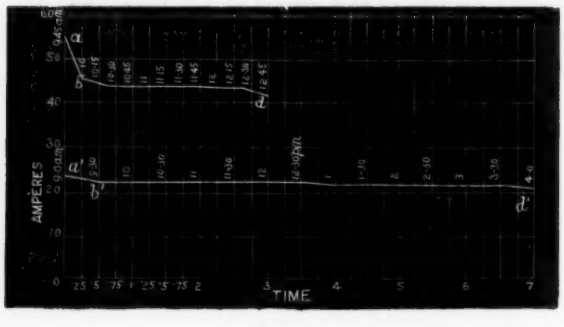


FIG. 1.

we plot in fig. 1, current in ampères, in fig. 2, E.M.F. in volts, and in fig. 3, energy in watts. On each diagram there are two "curves," one showing the discharge at a high rate (Table I.), and the other at the normal working rate (Table II.) of one and the same cell.

Fall of E.M.F. and Current.—Let us examine the whole process by means of the curves thus plotted. Looking at fig. 2, we observe a rapid fall during the first few minutes between the points *a*, *b*, on the one and a^1, b^1, on the other. This drop in the current density was partly due to an increase in the external resistance which was composed of iron tape, and which resistance rose slightly as the metal got heated, but a very similar and sudden decrease of current always takes place in a fully charged lead accumulator, whose

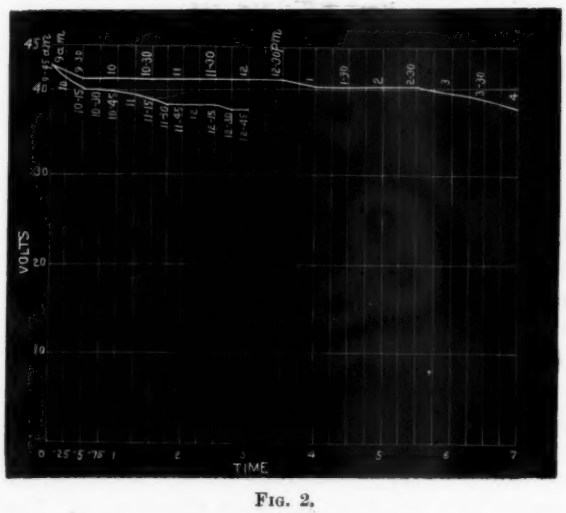


FIG. 2.

initial E.M.F. is generally between 2·15 and 2·25 volts per cell, and which high E.M.F. is due to the gases suspended on the surfaces of the plates; we have, in fact, at the first instant a gas battery, the spare oxygen or ozone of which is speedily consumed. Another cause of this diminished intensity, according to Dr. Lodge, lies in the fact that as the surface hydrogen disappears, a scum of sulphate is formed on the negative plate; this film of sulphate increases the internal resistance of a cell more than it diminishes the E.M.F., but it considerably reduces the strength of a powerful current. The greater the current rate, when the cell

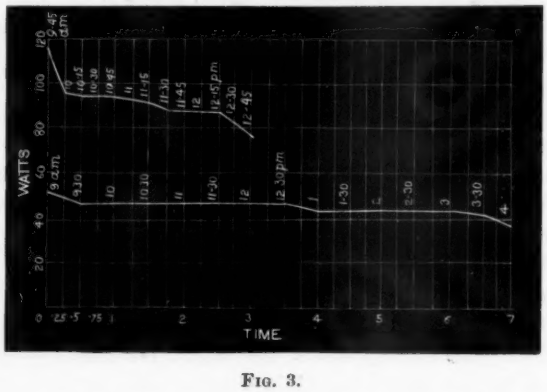


FIG. 3.

is being discharged, the more will be the resistance offered by this scum, and this is the main reason why a cell refuses to give very strong, and at the same time, constant currents for prolonged periods. "On allowing the cell to stand," says Dr. Lodge, "the scum clears off, and the original power is to a great extent restored. And there is this to be noticed about the scum, that the faster it is formed the faster it clears off. If it is formed very rapidly by a very powerful current, the cell need not stand long to recover itself."

The clearing away of this insulating film is supposed to be due to "the local action between the dehydrogenised lead in the deeper layers of the coating and the hydrogenised lead of the surface; and if this is so, there must come a time when the film will refuse to clear off, and a permanent increase in the internal resistance will set in, increasing as the action penetrates deeper and deeper into the negative coat, until the still metallic lead can only be reached by penetrating through a surface layer of non-conducting matter, consisting mainly of sulphate, but also," Dr. Lodge thinks, "of the lower oxides of lead."

Professor Herschel made experiments some four or five years ago with a clean lead plate, and a plate coated with peroxide, both being immersed in diluted sulphuric acid; he discovered that a non-conducting film of sulphate was formed on the clean plate the instant it was used to produce a current, which effectually screened the liquid from the metal, and thereby caused an increase in the internal resistance. This scum never forms when the negative plate is standing idle in the acid, it can only form when the circuit is completed. Recharging the cell removes the scum from the negative lead strip, not apparently by reducing it, but by making it peel off. If, instead of using a clean homogeneous lead plate, we employ spongy lead, exposing a very large surface, then this film takes a much longer time to form. The constancy of the current depends upon the amount of hydrogen occluded, consequently the *rate* of discharge must be in proportion to the total available surface. The diagrams before us illustrate this most forcibly; assuming that the rapid fall during the first 15 minutes is partly due to temporary causes indicated at the beginning of this paragraph, we still find that in the endeavour of working the cell at a very high rate, the current is reduced from 46·65 to 40·66 ampères in the course of 2·75 hours, whereas at a reasonable rate of discharge the difference is only 1·86 ampères during 6·75 hours. We can only obtain a large working surface within a small space, by using finely divided lead, oxides of lead reduced to spongy, lead for the negative plate; it is furthermore important that the layer of spongy lead be of a moderate thickness, because full activity will only take place to a certain depth, since the acid can either not penetrate sufficiently into the porous mass, or it gets speedily exhausted within as it combines with the lead, and clogging occurs beneath through the non-conducting products thus created. In order to facilitate diffusion with the main body of the liquid, the plates must be comparatively thin; in fact, the thinner they are the greater is the activity, and the more constant the discharge, always provided that the *volume* of porous material bears a certain relationship to the total capacity of an accumulator.

Sulphating.—The formation of sulphate of lead, on lead plates immersed in sulphuric acid, is a natural consequence. Sulphate is a necessity; without it the charge could not be retained for a long time, and, above all, it prevents local action between the metal and its oxides, but a superabundance of this compound of lead is detrimental to the life and proper function of a secondary battery. Whilst charging, the lead sulphate on the plates is decomposed and re-formation of sulphuric acid takes place, so that ultimately the strength of the solution is fully restored. On discharging again, lead sulphate is produced on both the positive and negative plates, and thereby the strength or specific gravity of the acid becomes diminished.

Strength of Acid.—Concentrated sulphuric acid is a bad conductor, so is pure water, but a mixture of the two furnishes a good conducting medium. The best density of the mixture depends upon various circumstances: if the acid is too strong there is a tendency of an excess of sulphate being formed on the plates, causing them to expand and finally buckle when discharging; if the solution is too weak, then there is the danger of almost pure water being left at the end of the discharge, and consequently great internal resistance. When a cell is newly made up with "formed" plates and the acid is put in, the specific gravity will drop immediately, indicating the formation of sulphate; on charging the cell the strength of the acid will gradually rise again. Tables III. and IV. were prepared with a view of illustrating this phenomenon. There were three cells used, A, B, and C, of equal size and capacity; cell A was filled with acid of 1,100° (water taken at 1,000), B 1,125, and cell C with acid of 1,200. Immediately after pouring the liquid into the boxes circuit was made with the charging apparatus, but some 20 ampères for one hour were expended before any change in the density of the liquid took place;

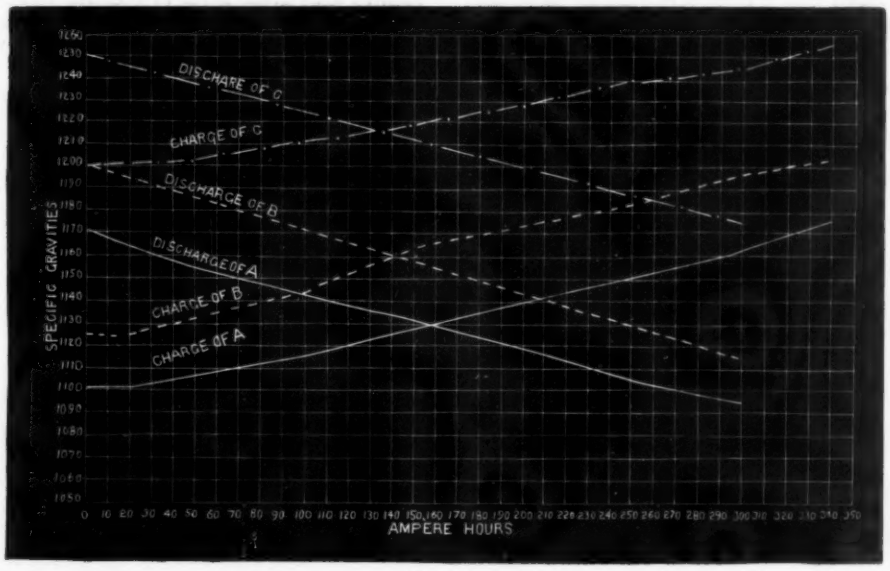


FIG. 4.

TABLE III.—CHARGING CELLS.

Ampère hours.	Densities of acid.		
	A.	B.	C.
0	1100	1125	1200
20	1100	1125	1200
50	1105	1133	1203
100	1115	1143	1211
150	1127	1164	1218
200	1139	1174	1229
250	1150	1184	1240
300	1162	1200	1245
340	1175	1208	1256

TABLE IV.—DISCHARGING CELLS.

Ampère hours.	Densities of acid.		
	A.	B.	C.
0	1170	1200	1250
50	1155	1184	1238
100	1143	1168	1227
150	1132	1154	1215
200	1118	1141	1202
250	1104	1129	1189
300	1094	1115	1176

there was even a tendency of the specific gravity falling in spite of the charging operation; thus there must have been a kind of equilibrium between two opposing forms of energy; one struggling to produce sulphate and the other struggling to reduce it.

After this expenditure of 20 ampères of current at some 2·38 volts E.M.F. per cell, the specific gravity began to rise almost in proportion to the amount of charge put into the cells. Diagram, fig. 4, will show the effect more strikingly than the tables; the charge in ampère hours is taken for the abscissæ and the specific gravities for the ordinates. The acid of A which was at the start 1,100, rose to 1,175; that of B rose from 1,125 to 1,208 and the density of the acid in C went up from 1,200 to 1,250, all with a charge of 340 ampère hours. The cells were left standing over night; next morning on observing the hydrometer (or acidometer) the densities stood at 1,170, 1,200 and 1,250 respectively for A, B and C, giving a reduction of 5, 8, and 6 degrees in the liquids. This discrepancy may be attributed to three causes: firstly to a slight formation of sulphate; secondly to surface leakage; thirdly, and, perhaps, *mainly*, to strata of different specific gravities in each cell. The liquid in the lower portion of a newly charged cell is generally slightly more acid than that near the surface; the hydrometer bulb dipped into the lower part of the vessel and therefore did not indicate the *average* density, if the assumed strata existed. Theoretically the acid "curves" of fig. 4 should all be straight lines—they are so approximately only, and the irregularities are no doubt due to the last-mentioned causes. Diffusion of the liquids can be assisted by stirring, but it will be observed that in doing so large gas bubbles float up immediately which may mean some loss in the capacity; towards the end of the charge, if the same is carried to completion and the liquid is allowed to "boil," by a little overcharging, the acid gets stirred up automatically. A, B and C were not overcharged.

(*To be continued.*)

ELECTRIC ILLUMINATION IN LEEDS.

ONE of the most intelligently-conducted of provincial journals, the *Leeds Mercury*, last Saturday addressed itself to the subject of electric lighting in these terms:—"We have often touched upon the subject of electric illumination generally, recognising the advantages of this method of lighting, and also the many hindrances its advocates have had to contend with. The telegraph and the telephone have had a comparatively clear field for progress, while the electric light, in this country especially, has had to fight for every inch of ground, owing to the apathy, prejudice, suspicion, and even hostility of the public. Absurd and unworthy of the nineteenth century as these feelings may be, they have hitherto prevailed to a very large extent; but just as after a hard struggle the railway won in the end, so will the electric light. Several years have now elapsed since it was first practically introduced into this borough; and it will be interesting to our readers, and will serve to mark the progress of a phase of civilisation among us, if we give approximately the numbers of machines, lamps, &c., at present available or in use in Leeds. Of electric light dynamos of various sizes and descriptions there are about 35, besides several kept for occasional use. Primary batteries for lighting are at present only resorted to for medical and theatrical purposes, and for private amusement. Secondary batteries, or 'accumulators,' are employed at present only to a very limited extent, but up to the present give great satisfaction. Over 130 arc lamps of various kinds are in more or less regular use, chiefly in engineering works, factories, dye-houses, and colour-printing works, where their pure white light enables work to be continuously done that otherwise could only be done at intervals with bright daylight. Of incandescent lamps there are about 2,600, but the machinery is only equal to working about 2,000 at any one time. Incandescent lamps are used in the Public Library Department of the Municipal Buildings with complete success, save that more lamps in certain parts would be an advantage. There is an easy possibility of partial lighting during the daytime of that side of each room which most needs it, where, we are sorry to say, gas is burnt with manifest disadvantage, the effect of gas on books and decorations being ruinous. Incandescent lamps are also used, when required, in the Victoria Hall, as at the musical festivals, &c. The Coliseum Company, ever since the opening of their fine building, have had a most complete installation of incandescent lighting at work on the premises with full satisfaction. The lecture hall and library of the Philosophical Hall are lighted by incandescent lamps from dynamo or accumulator. The Albert Hall is partially lighted occasionally from an accumulator. At the Yorkshire College, in a well-known bank, in two flour mills, extensive business premises near Boar Lane, and in several private houses, offices, and shops, these lamps are used, always giving satisfaction when properly fitted up and steadily worked. 'Anything that is worth doing at all is worth doing well;' and this applies with great force to electric lighting. It is unreasonable to expect satisfaction unless the work is carried out properly, and this can only be done by qualified men, adequately paid. The first cost is the chief expense, and here it is that people sometimes make the mistake of putting lowness of price before everything. Electric lighting is one of the greatest advantages we can possess in the way of illumination. Even if a little more costly than other lights, its beauty, purity, steadiness, with its low heating effect, give it an unapproachable superiority over every illuminant which it has been within the power of human ingenuity to produce."

REVIEWS.

Practical Electricity: A Laboratory and Lecture Course for First Year Students of Electrical Engineering, based on the Practical Definitions of the Electrical Units. By W. E. AYRTON, F.R.S. Cassell and Co., Limited, London, Paris, New York, and Melbourne.

This book is undoubtedly one of the most useful and most original electrical works that has been brought out for some time; we have no hesitation in describing it as a most excellent production, and we think great thanks are due to Prof. Ayrton for having published it. The author is evidently thoroughly cognisant of the many difficulties which learners meet with in studying, and he entirely avoids the mistake (which is very general indeed amongst those professors who deal with the higher branches of science) of taking for granted that what is perfectly clear to himself is necessarily equally clear to others. We entirely agree with Prof. Ayrton that the proper way to teach the subject of electricity (if not other subjects) is *analytically* and not *synthetically*; the example given to prove this is, we think, very much to the point; thus the author says:—"It is not by studying geometrical optics, much less physical optics, that an infant gradually learns to appreciate the distance of objects; and later on it is not by studying a treatise on struts, nor by listening to a course of lectures on structures, that a child finds out that the table has legs, hard legs, round legs. Feeling, looking, trying, in fact a simple course of experimental investigation, gives a child its knowledge; and this, therefore, I venture to think, is the method we should adopt when commencing the study of electricity."

Abandoning the old well-worn grooves, Professor Ayrton has arranged the order of the various parts of the subject treated of in an original way, and with excellent reason; current is first dealt with, because "in almost all the industries in which electricity is practically made use of, it is the electric current that is

employed." In reading over this part of the subject one is at once struck with the happy analogies which are used to explain certain points which are liable to be misunderstood by the learner; such analogies are constantly made use of throughout the work, and with the best possible effect; great care is taken that an incomplete analogy may not be assumed to be complete, and the points where it fails are very clearly pointed out. The very free use of numerical examples is a valuable feature in the book, and adds most materially to its utility. In dealing with the definitions of certain of the units Prof. Ayrton proceeds in a manner which, though we heartily commend it, would, we feel sure, call forth a storm of sarcastic criticism if the author of the book had been either nameless or but little known. Unit current, we are usually told, is the current which is produced in unit resistance by unit potential, a definition which practically leaves the learner as wise as he was before he obtained the information. Prof. Ayrton, however, commences by giving the reader a plain numerical example of what a unit current *will do, i.e.*, the amount of silver it will deposit from a nitrate solution in a given time, and says, this "we shall call an ampère and take it as our unit current." As the reader continues his studies, the exact relationship which current bears to potential and resistance, &c., becomes clear to him almost unconsciously.

Prof. Ayrton does not spare the philosophical instrument makers, and points out the absurd and utterly unsuitable forms in which many of the stock instruments made by them for educational purposes are constructed. The makers themselves are perhaps not so much to blame in the matter as are the professors who teach science, and who are mostly thoroughly unpractical, however well they may be versed in the theory of the subjects they teach.

In Chapter II., which deals with galvanometers, we have an excellent exposition of the laws which govern the action of these instruments, the apparatus which have been designed for explaining the elementary principles being illustrated, and being of a very suitable character. On the subject of tangent galvanometers we have the following excellent remarks, which indeed are typical of the attention which is paid by the author throughout the book to practical details:—"Beginners are apt to think that, because the divisions on a tangent scale are very much crowded together in the higher part of the scale, the value of a current can be more accurately ascertained by taking a reading on the degree side, and then finding the value of the tangent in a table of tangents, than by reading it off on the tangent scale. But this seeming greater accuracy is quite delusive, since what has to be ascertained in either case is the tangent of the angle, not merely the angle, and although on the degree side of the scale the angle can be read much more accurately than can be its tangent, or a number proportional to its tangent, on the other side, this only indicates that the error of a tenth of a degree in a large angle, although a much smaller proportional error than a tenth of a degree in a smaller angle, produces a far greater proportional error in the tangent."

Chapter IV., which deals with "Resistance and its measurement," is particularly good, the portion in which the work done in an electric circuit is considered being especially clear.

We notice that in Chapter V., where Poggendorff's method of comparing E.M.Fs. is explained, the statement is made that "the great advantage of the method is that the comparison is made when *neither* of the batteries is sending a current. This is quite true if the test is made in the way explained by Prof. Ayrton, but this way is not the one generally understood as Poggendorff's method, in which one of the batteries *does* send a current: the statement is therefore, we think, liable to mislead.

We observe in Chapter VII. that amongst other things the question of the amount of energy which a charged condenser possesses is dealt with, also the amount of waste which takes place when a battery charges a condenser is gone into. We do not remember ever having seen this question explained before in any text book.

To go through the whole of Prof. Ayrton's book in detail and point out its many good features would occupy far too much space; in conclusion, we would state that we have read through the book with great pleasure and profit, and we can most strongly recommend it as being by far the best work of the kind yet published.

The Electric Motor and its Applications. By T. C. MARTIN and J. WETZLER. New York: W. J. Johnston.

This handsome quarto volume, with its two hundred excellent illustrations and irreproachable "get-up," is probably the most complete popular manual on this branch of electrical engineering which so far has been published. It does not profess to be an original work, being avowedly based largely upon articles from a variety of sources which have appeared in the *Electrical World* of New York. Many of these articles are already familiar to readers of these pages. A work which does not aim at being exactly original may, however, be very useful in its way, especially to those who like to have in a collected form, convenient for reference, the descriptions and articles of recent appearance on the special subject treated of, which are scattered amongst the various journals and transactions. But this book is much more than a mere compilation and arrangement of recently published articles from the technical and scientific press. A short opening chapter on elementary considerations is followed by a still shorter one on early European experiments, succeeded by a rather lengthy chapter on numerous early experiments and forms of motors of American origin. Amongst these early American motors is one which, although only very briefly alluded to, appears to have had some points of resemblance to the Siemens-Alteneck drum dynamo or motor. We are told that in 1852 Vergnes exhibited a motor which consisted of "elongated loops of copper wire revolving between the poles of powerful and colossal electro-magnets." The description, or rather reference, is too short to enable any opinion to be formed as to what this motor was, but if the Siemens-Alteneck armature should prove after all to have been first invented by an American, it will do something to justify the affection for it which many American inventors have displayed, and which has hitherto generally been supposed to have had its foundation in the absence, or weakness, of patent rights in that particular form of machine. At this side of the Atlantic we may be allowed to console ourselves with the knowledge that Vergnes was not a "real" American, he having left France, his native country, in 1830, he and the century being of the same age. To some other examples of early American proposals or experiments a reference will be necessary later on.

Chapter IV. deals with the history of practical applications of power-transmission and to a certain extent with the theory of the subject. There is a pretty full account of Deprez's experiments, and descriptions of the apparatus with which all are familiar. It is, perhaps, not worth while to do more than mildly protest against the statement that the reduction of the resistance of a line was "first proposed by M. Maurice Levy, in February 1882, in a note to the French Academy of Sciences, wherein he says that 'the resistance of the exterior circuit can be made very small, even for long distances, by employing a large wire.'" Attention is in this chapter again directed to the question of the actual invention or discovery of the electrical transmission of power, by the reproduction of some articles which some time ago went the round of the scientific papers. It will be remembered that M. Hippolyte Fontaine claimed this discovery on the ground that at the Vienna Exhibition of 1873 he used a Gramme dynamo, driving a Gramme magneto machine as a motor through about two kilometres of cable.

There is another version of this story, according to M. Figuier, who relates that the discovery was accidentally made by a workman at this same exhibition, who found that one machine revolved when connected by cables to the other. It is always an unpleasant task to disparage the results obtained by an inventor; and it is perhaps difficult to separate invention or discovery from mere application; especially when, as in this instance, a considerable time has elapsed, and enormous strides have been made in our knowledge, since the invention, discovery, or application was made. Nevertheless, it must be confessed that the doubt has not been removed which crossed the writer's mind on reading M. Fontaine's article—and which probably was present in the minds of most readers of that article—as to whether there was any justification for a claim on his part, or on the part of anyone else, to any special merit in connection with this matter. It seemed, and still seems, that the principle of the electrical transmission of power could be traced back a great deal further than the Vienna Exhibition of 1873. Electro-motors, and even their reversibility, were known even long before Pacinotti—witness Barlow's wheel and Faraday's disc, where there was actual rotation. The transmission of the electric current over long distances was also perfectly familiar. Given the facts then, that mechanical production of electricity was well known; that the operation of motors from batteries and other sources through short lengths of wire was familiar; and that the current could be sent through wires of almost any length; is it not correct to say that in 1873 the electrical transmission of power was waiting only for its application, and not for its invention or discovery. The mere knowledge of the possibility of transmission appears to be older than has been stated. The important practical questions of the economy of such transmission are another matter, and one which, we believe, was not touched upon by M. Fontaine at that time.

And we need go no further than the volume under consideration to find a confirmation of the belief that the idea of the electrical transmission of energy existed at any rate as an undeveloped invention at a comparatively early date. The chapter on "Early Motors and Experiments in America," to which reference has already been made, closes with an interesting account of the proposals as far back as 1840 of one Henry Pinkus, who patented the transmission of the current to electric car motors by means of the rails; and not only was this principle thus early indicated by Pinkus, but while describing the use of some forms of voltaic battery we are told that he anticipated and mentioned the future use of "mechanical generators which should be more economical than the batteries"—and this was to be expected, seeing that Faraday's researches ten years earlier had stimulated invention in mechanical generators, the machines of Pixii, Clarke, Saxton, and many others, being no doubt well known to Pinkus—so that we have here, in addition to the transmission of power to a distance, the broad principle of the electric railway. In this connection mention is also made of the electric locomotive devised in 1847 by Lilley and Colton, in which a circular track was used, the locomotor being driven by current picked up from the rails, which were insulated, one being connected to each pole of a voltaic battery; the motor appears to have belonged to the numerous class depending upon the alternate attraction and repulsion of electro-magnets. And at a later date—1861–1864—Pacinotti pointed out not only the reversibility of his famous machine, but indicated how it could be used for the transmission of power to a distance. The passage, which is from the famous description in *Il Nuovo Cimento*, is given in the work under consideration. It is as follows:—"This model further shows how the electro-magnetic machine is the complement of the magneto-electric machine, for, in the first, the current obtained from any source of electricity circulating in the bobbins produces movement of the wheel with its consequent mechanical work; whilst in the second, mechanical work is employed to turn the wheel, and obtain, by the action of the permanent magnet, a current which may be transmitted to any required point." Thus it is evident that Fontaine, while deserving great credit for having in 1873 made a practical demonstration of the transmission of power to a distance, can scarcely be considered to have first invented or discovered electrical transmission.

The question of the calculation of the size of conductors for a distribution system where motors are the principal "translating devices" is much more difficult and uncertain than for electric lighting—which is saying a good deal—for the reason that in the former there is introduced the generating action of the motors which, from any cause, are being made to produce current instead of absorbing it. This property of an electric motor system, the writer believes, was first noticed by the late Sir Wm. Siemens, who stated that "two trains on the same pair of rails, one ascending and the other descending a grade, influenced each other through the common current as absolutely as if connected by an actual rope." The fact is very interesting, as also is the characteristic expression of it by Sir Wm. Siemens. In connection with this feature it is quite possible to imagine in a system where railways, hoists, winding and hauling plant, are being operated by electric motors, that it might happen that all the motors were being driven, not by the current supplied to them, but by their own attached apparatus, running down hill and the like; and that the ordinary conditions of the system might be reversed; the main generator at the central station becoming a motor, "running away" with its engine, in obedience to the higher E.M.F. and consequent current received from the mains. Although this condition is not likely to happen in practice it is a distinct possibility, which might be brought about by a number of motors attached to trains or hoists engaged for the time being in carrying loads down, while only the empty cars or cages had to reascend.

But however difficult it may be to calculate mains for a distribution system which includes a large number of motors, there is less difficulty when a simple case of transmission from one point to another is concerned; and it may be well to point out that the treatment of such a problem in Chapter IV. is not very satisfactory. The object, certainly, is stated as being "rather to suggest a method of dealing with such questions than to furnish absolute results," but even with this qualification in view it is necessary to point out that the results obtained are not reliable. Thus it is stated that "the amount of power to be circulated in the form of current is 500 horse-power." This is not a satisfactory way of expressing the case, and would not be even if 500 H.P. had to be given to the mains. It appears, however, that 500 H.P. is available at the prime motor—which is a very different thing. And after this is brought down to 2,642 ampères × 120 volts by the loss in the first conversion, a pair of leads having a resistance of ·035 ohms is trusted with the "circulation." Those who are curious can readily find that at the distant end of the line to which, in this case, all the power is to be transmitted there would be required a motor which would receive 2,642 ampères with a potential difference of 27·5 volts. There are other points in which the results arrived at does not accord with English practice, but these need not be further alluded to.

Electric railways and tramways in Europe are dealt with in the next chapter, the various lines of Messrs. Siemens are mentioned; Dr. Traill's account of the Portrush line is given; and thanks mainly to the energy and perseverance of Mr. Holroyd-Smith, England is able to receive a passing notice.

The account of electric railways and car lines in America is very interesting, the various descriptions being excellently supplemented by engravings, many of which are working drawings which will be examined (or re-examined, for some of them are old friends) with interest by all practical readers. "The Use of Storage Batteries with Electric Motors for Street Railways" has a chapter to itself, containing references

to all, or nearly all, the experiments made in this direction in Europe. Captain Douglas Galton's report on the competitive trials at Antwerp is quoted, and Mr. Reckenzaun's work receives due recognition. There is also an appendix on M. Jullien's system, which is being introduced in America.

It is a little strange that the introduction of accumulator-driven cars has never been attended with great success in this country. Is the hitch with the cells, or the motors, or the gearing, or is it with the tramway companies? This book does not contain an answer to the question. It is to be hoped that we shall soon see a renewal of the efforts to place cars of this description on some of the metropolitan lines. The fact that they are self-contained, and necessitate no alteration of the track, is an enormous advantage, which alone should enable them to hold their own.

"Industrial application of electric motors in Europe and in America" we must pass over, although many interesting examples are mentioned. The dearth of small motors of good design appears to indicate that there is no genuine demand for such articles. There is, however, certainly some improvement in this direction, although many of the motors are still of a very elementary kind. The little Griscom motor continues to hold its place, in spite of its very low efficiency. This is remarkable. Seeing that it is usually run from voltaic cells one would imagine that low efficiency would be fatal to it. It is stated that one of these motors, weighing 40 oz., can develop one-sixth of a horse-power without difficulty, but this must be an error. It will be remembered that Profs. Ayrton and Perry in their experiments found that the greatest power that could be obtained from a Griscom motor of this weight was ·015 H.P. with an efficiency of about 13 per cent. (*Jour. Soc. Tel. Eng.*, vol. xii., p. 368.)

The interesting telpherage systems of Profs. Fleming Jenkin, Ayrton and Perry, an account of which is given, is so well known from the numerous descriptions which have been published that it need only be mentioned for the purpose of expressing surprise and regret that what appeared so promising an invention should have met with so insignificant an amount of actual application. The writer believes he is not committing a breach of confidence in stating that unexpected practical difficulties, partly electrical and partly mechanical, have been met with; the principal one being the inability of the motors to withstand exposure and remain in good working order for any length of time. These difficulties are now believed to have been overcome. It is easy to understand that, in a climate like ours, the problem of working with any potential-difference large enough for economy must be by no means an easy one to solve. The reasons which have always made closed-circuit telegraphy a failure in this country must apply with increased effect in telpherage (a closed circuit system), where the tension is much higher than in telegraphy, and the difficulties in connection with supplying and insulating the conductors very much more serious. There is a probability that the climate of the United States, which has enabled closed-circuit telegraphy to become general, may be similarly kind to telpherage systems, and in the chapter on the subject some designs are given which certainly look very practical. They are, for the most part, strong cable roads, capable of carrying heavy loads of freight and passengers, the motor being under the control of a driver. The idea of the originators of telpherage was to make their system self-acting, to do away with attendants except at the stations, for loading and unloading, and in fact to compete rather with horse and cart than with the locomotive engine; and probably they were right in their views. It remains to be seen whether American electrical engineers can educate the public to allow themselves to be whirled through mid-air in baskets dangling from a wire rope, or even supported between two such ropes. Judging from the illustrations, the sensation would be more novel than agreeable. By this means it might, however, be possible to get into training for aerial navigation, in which electric motors have been used with such success that M. Tissandier says that the question is now only one of capital. It is reassuring to learn from the same authority that the aerial ships of the future, which are to attain a speed of 26 to 33 miles an hour, are to "remain in port, as other vessels do, when the wind is high."

The last chapter in this very interesting book is a very readable one on the latest American motors and motor systems, but as most of the matter contained in it has appeared in the columns of this Journal, it is not necessary to occupy much space in dealing with it, especially as more than half of it consists of an account of the Sprague system which has already received notice. Although Mr. Sprague has laid himself open to—and has received—criticism on one or two points, there is no doubt that he has worked out his railway system in a thoroughly able and practical manner. It deserves, and will no doubt receive, careful study by all who take an interest in the subject. It is to be noticed that the principle of utilising the generating power of a motor, already alluded to, has been applied by Mr. Sprague in a very neat manner for the purpose of braking the train. The strength of the field is increased when it is desired to apply a braking action, until the E.M.F. rises sufficiently to convert the motor into a generator. The field being then gradually strengthened as the speed falls, the generation of useful current continues until the mains have the same tension as the dynamo, when the armature is switched on to an artificial resistance, the fields continuing to be excited from the track; thus, until actual stoppage occurs, the brake is kept on, for most of the time usefully, because it is supplying current to the mains.

Although, as will have been seen from these remarks, a little more discrimination would have been an advantage in the preparation of some parts of this work, it may as a whole be highly recommended.

W. M. MORDEY.

ON THE LIMITING DISTANCE OF SPEECH BY TELEPHONE.*

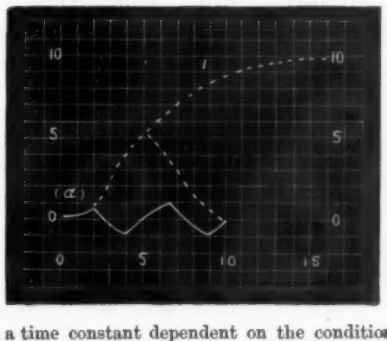
By WILLIAM HENRY PREECE, F.R.S.

THE law that determines the distance to which speaking by telephone on land lines is possible, is just the same as that which determines the number of currents which can be transmitted through a submarine cable in a second. The experimental evidence upon which this law is based was carried out in 1853 by Mr. Latimer Clark (whose assistant I then was). The experiments were made by me in the presence of Faraday; many were his own; he made them the subject of a Friday evening discourse at the Royal Institution, January 20th, 1854, and they are published in his "Researches" (vol. 3, p. 508). They received full mathematical development by Sir William Thomson in 1855 (Proceedings Royal Society, May 24th, 1855), who determined the law, the accuracy of which was proved by Fleeming Jenkin and by Cromwell Varley, and the 110,000 miles of cable that now lie at the bottom of the ocean afford a constant proof in their daily working.

Hockin reduced Thomson's law to the following series:—

$$x = c\,(1 - 2\{(\tfrac{1}{2})\,t/a - (\tfrac{1}{4})\,4t/a + (\tfrac{1}{4})\,9t/a - (\tfrac{1}{4})\,16t/a + \&c.\}),$$

which allows it to be expressed in the following curve (1):—



Now a is a time constant dependent on the conditions of the circuit, invariable for the same uniform circuit but differing for

* Paper read before the Royal Society, March 3rd, 1887.

different circuits. It represents the time that elapses from the instant contact is made at the sending end to the instant that the current begins to appear at the receiving end. It is given by the following equation :—

$$a = \text{B}\, k\, r\, l^2,$$

B being a constant dependent principally on the units used; k the inductive capacity per unit length (mile or knot); r the resistance per unit length, and l the length in miles or knots.

a, therefore, limits the number of vibrations per second that can be sent through any circuit. If a be 0·196 second, as it was in the French Atlantic cable of 1869,* 2,584 knots long, then it is impossible to send 5·1 currents per second through that cable; but it would be possible to send 5 or 2½ complete reversals per second. Moreover, as the number of reversals varies inversely with the square of the length, it shows that such a cable if of 100 miles length would allow 1,562 reversals to pass through it. It is necessary to remark that these expressions involve no mention of E.M.F., or of current, and therefore the number of reversals which can be produced at the end of a wire is quite independent of the impressed E.M.F., and therefore of the strength of the current. But the number of reversals is dependent upon the sensitiveness of the apparatus used to receive the currents, for if we use an instrument which will respond to a current indicated by the full line, we get two currents per second: and if we use an instrument which will respond only to the dotted line, we get only one current in two seconds, which is about the current used with delicate relays in this country. This is why such discordant results are obtained by different observers who attempt to measure the velocity of currents of electricity. It is also why the telephone is such an admirable instrument for research—for it is sensitive to the least increment or decrement of current.

Before proceeding with this inquiry it was necessary to determine very accurately the inductive capacity of overhead and underground wires. This was done with great care on very dry days in different parts of the country by means of a Thomson mirror galvanometer and a standard condenser.

The results come out as follows :—

	Capacity per mile, microfarads.	Resistance per mile, B. A. ohms.
No. 7¼ iron wire	0·0168	12·0
No. 12½ copper wire	0·0124	5·7
Gutta-percha covered wire in iron pipes	0·2500	23·0
Gutta-percha covered wire in cables ...	0·2900	10·25

The capacity can be calculated from the following formula (also due to Sir William Thomson) :—

$$\text{K} = \frac{l}{2 \log. (4\, h/d)},$$

where d is the diameter of the wire and h the height above the ground. Taking h at 500 cm. and d at 0·243 cm., the capacity comes out for 12½ wire at 0·0113 instead of 0·0124 microfarad per mile. The cause of this difference is referred to further on.

It then became necessary to determine the speed of the current through wires of different lengths, resistances and capacities.

A multiplex distributor—such as we are now using in the Post Office—enables this to be done with great accuracy. At each station a circle is broken up into 162 sections, and an arm in connection with the line wire carrying a brush sweeps over these sections and makes contact. This arm can be made to rotate at any speed. If it makes three revolutions per second it will make

TABLE SHOWING THE SPEED OF CURRENT THROUGH WIRES.

Wire.	Route.	Length in miles.	Total resistance × Total capacity.	Speed of current in seconds.	Telephonic notes.
Nos. 142 and 144, Denham and Atherstone	New West Coast ... Open ..... Covered	90 2·5	2247·0	0·0007 calculated.	Gower-Bell Telephone. Speaking good.
London and Denham	Underground	21	2963·5	0·0009 calculated.	Ditto ditto.
Nos. 142 and 144, Denham and Stafford	New West Coast ... Open ..... Covered	119 5	4715·7	0·0015 calculated.	Gower-Bell Telephone. Speaking fairly good.
South]Wales	..... Open ..... Covered	79 1·25	5680·0	0·0016 calculated.	Gower-Bell Telephones, working satisfactorily.
Newcastle Telephone system, Warkworth to Stockton P.O.	*Vid* Newcastle Sunderland and West Hartlepool. Open ... Covered	63·831 12·039	5817·6	0·0016 calculated.	Gower-Bell Telephones. 5 intermediate electro-magnets of 1,000 ohms resistance, in derived circuit. Speaking satisfactory.
Nos. 142 and 144, London and Towcester	New West Coast ... Open ..... Covered	50 21	7341·3	0·00234 calculated.	Gower-Bell Telephone. Speaking weak, but just able to hold a conversation.
Nos. 142 and 144, Denham and Nantwich	Ditto. Open ..... Covered	146 7	7612·1	0·0034 calculated.	Gower-Bell Telephone. Speaking weak, but just able to carry on a conversation.
London to Denham (with additional loop between Denham and Hanwell) ...	Underground	39	10221·0	0·0032 calculated.	Gower-Bell Telephone. Speaking good, but approaching the point of difficulty.
Nos. 142 and 144, Denham to Warrington	New West Coast ... Open ..... Covered	172 8	10399·16	0·0038 calculated.	Only just able to speak. Impossible to carry on conversation.
Nos. 142 and 144, London to Atherstone	Ditto. Open ..... Covered	90 23·5	12511·2	0·004 calculated.	Only just possible to speak.
New Irish cable	Cable .... Open ..... Covered	25 62·9	12587·4	0·00412 observed.	Berliner's Telephone. Only just able to talk.
Newcastle district	..... Open ..... Covered	30 30	12640·0	0·00412 calculated.	Requires very good telephones and very good voices.
Copper. London to Nevin (land lines for the new Irish cable)	*Vid* Worcester and Shrewsbury Open ... Covered	251·18 18·5	15771·5	†0·0035 observed.	Berliner's Telephone. Some voices good.
No. 11, London Stock Exchange to Liverpool Stock Exchange (Iron wire, No. 8 gauge)	*Vid* London and N.W. Railway ... Open ..... Covered...	199·014 7·243	16417·8	0·005 observed.	Telephone not tried.

N.B.—The speed is calculated from the formula $t = 32 \times 10^{-8}$ K R.

* Fleeming Jenkin, "Electricity and Magnetism," p. 331.

† The constant for copper is 22×10^{-8}.

the duration of each contact $\frac{1}{1\,0\,0}$th of a second. Now the two distributors are kept running in absolute synchronism, so that the brush at each station always rests simultaneously on corresponding sections. The sections at one station can be placed in contact with the battery, and those at the other station with a galvanometer or other sensitive apparatus. If the current traversed the wire instantaneously, then it would appear on the same section at the same time on the galvanometer; but the current is always retarded, and the amount of retardation or the value of a can be measured and the curve of arrival and cessation drawn by watching the indications of the galvanometer on each succeeding section.

The following table summarises a large number of experiments that have been made in different parts of the country, and on different lines, to determine by observation the connection that exists between speed of current, distance spoken through, resistance and capacity. The maximum current, or the crest of the wave, was observed. This was equivalent to 0·003 ampère.

It will be seen that the limiting distance through which it is possible to speak varies inversely with the speed of the current, and that the speed of the current varies inversely with the product of the total resistance and the total capacity of the circuit. Hence we can say that the number of reversals that it is possible to send through any circuit varies inversely with the product of the total resistance (R) and the total capacity (K), or the limiting distance

$$S = K R \times \text{constant.} \qquad (1)$$

This is only another form of Thomson's law for $K = l\,k$, and $R = l\,r$, and

$$\therefore S = k\,r\,l^2 \times \text{constant.}$$

It is seen that when the speed of the working current was
0·001′ speaking was perfect,
0·002′ speaking was good,
0·003′ speaking was fair,
0·004′ speaking was difficult,
If we put equation (1) into this form,

$$A = k\,r\,x^2, \qquad (2)$$

and give to A the following values:—

Copper (overhead)	15,000
Cables and underground	12,000
Iron (overhead)	10,000

we can find the limiting distance we can speak with any wire; for

$$x^2 = A/k\,r.$$

Take copper, whose constant is 15,000, and a wire whose resistance 1Ω per mile, and capacity 0·0124 per mile, then—

$$x^2 = \frac{15{,}000}{0{\cdot}0124},$$

$$x = 1{,}100,$$

which is the limit of speaking upon such a wire.

The wire used between Paris and Brussels has a resistance of 2·4 ohms and a capacity of about 0·012 microfarad per kilometre, and as that distance is only about 200 miles the speaking must be excellent. Moreover, there is reason to believe, from the difference between observation and calculation, that the static capacity on Continental and American lines is less than that of English lines, owing to the use of earth wires on all poles in England, and therefore the distance would be greater.

Take an Atlantic cable—

$$x^2 = \frac{12{,}000}{3 \times 0{\cdot}43},$$

$$x = 96.$$

Now I had found in 1878* that it was just possible to speak through 100 miles of such a cable—a very close agreement.

Moreover, by the law of the squares, 100 miles of an Atlantic cable ought to transmit 1,562 reversals, if 2,584 miles transmit 2½, and this is probably the average number of sonorous vibrations imparted by the human voice, when hearing by telephone begins to get difficult by the loss of the higher partials and overtones.

There is another interesting consequence of Thomson's law which comes out of these experiments, and that is, whether the line be a single wire completed by the earth, or a double wire making a metallic circuit, the rate of speed between the two ends is exactly the same, and therefore the distance we can speak through is just the same whether we use a single or double wire circuit. This is owing to the fact that though in the latter case we double the total resistance, we halve the total capacity, and therefore the product remains the same.

The difference between copper and iron is clearly due to self-induction, or to the electro-magnetic inertia of the latter, and the difference between copper overground and copper underground is due to the facility that the leakage of insulators offers to the rapid discharge to earth at innumerable points, of the static charge, which in gutta-percha covered wire can find an exit only at the ends.

It is also evident that there is no difficulty in working telephones through underground wires, even though they attain 50 miles in length, and in fact it would be better to work underground with proper copper wire from London to Brighton, than to use iron wires along the railway telegraph poles, owing to the absence of external disturbances in the former case.

The limit of working of different insulated wires is easily obtained by equation (2), and the following table gives that information for different gutta-percha covered wires.

No.	k.	r.	Limit of speech.
20/11	0·270 mf.	45·00 ohms.	32 miles.
18/7½	0·250 „	23·00 „	46 „
16/4	0·240 „	13·00 „	62 „
107 lbs./150 lbs.	0·290 „	10·25 „	64 „

N.B.—The top number indicates the gauge of wire, and the lower number that of the gutta-percha.

* *Phil. Mag.*, April, 1878.

BRIGHTON ELECTRIC RAILWAY.

ENCOURAGED by the success of the recent County Court action against Mr. Volk, the opponents of his electric railway ventured upon another of their series of periodical attacks at the meeting of the Town Council on Thursday week, with a result thoroughly deserved. The initiative was taken by Councillor BLAKER, who, in accordance with notice, moved a resolution to the effect that in consequence of Judge Martineau's recent decision, Mr. Volk should be given notice to remove the electric railway within one month, in accordance with the terms of his agreement with the Corporation. In the course of his remarks, he contended that the railway was under no control whatever, and constituted such a danger that no prudent parents thought of sending their children to play on that part of the beach, and people were afraid of driving on the road above. Judge Martineau, after a careful investigation of the *locale*, and of the evidence in the case which came before him, came to the conclusion that the railway was dangerous and illegal, and, as a result, if anyone was injured in future an action might be brought against the Corporation; who would probably be mulcted in heavy damages. The railway was of no earthly use to them, and even if they obtained anything out of it they would not be justified in allowing it to continue after they had been distinctly informed that it was illegal.

The resolution was seconded by Councillor BERRY, who stated that several accidents had occurred, and narrow escapes were reported. When the extension was agreed to, the Works Committee promised that if any accident took place the railway should be abolished. Subscriptions were being solicited on behalf of Mr. Volk because he lost the recent action, and a more impudent thing he never heard of.

Councillor BOOTH charged the last speaker with making several statements of an exaggerated description, and pointed out how convenient the railway was to the east end of the town. He moved that the matter should be referred to the Works Committee.

In seconding the amendment, Councillor HALL said that many of the accidents alleged to have been caused by the railway were merely "got up" for the occasion, or misrepresented to the Council. Judge Martineau gave judgment on points which never came before him, and as the railway had carried over a million passengers it was useless to argue that it was not an attraction and that it was not appreciated by the public. He was authorised to state that Mr. Volk proposed, eventually, to remove the railway altogether, and he trusted that no steps would be taken in reference to the matter until the Works Committee had had laid before them what he intended to do.

Several speeches having been made, *pro et con*, Councillor STYER observed that the only opponents to the railway whom he had ever come across were Messrs. Carpenter, Berry, and one or two others. The people generally were strongly in favour of it.

Councillor GRIFFITHS, who followed, caused considerable laughter by stating that he was at the hospital when the boy who was said to have met with an accident through the railway was brought in, and the doctor, being unable after a careful examination to find a scratch upon him, told him that he had better go home and get his trousers sewn up.

Eventually the amendment was carried by 29 to 7.

Royal Society.—Dr. Hopkinson was announced to read a "Note on Induction Coils or Transformers," and a "Note on the Theory of the Alternate Current Dynamo," at the meeting of the Royal Society on Thursday afternoon.

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NATIONAL ELECTRIC LIGHT ASSOCIATION.

THE fifth meeting of this association was held last month at Philadelphia, under the presidency of Mr. J. F. Morrison, who stated that the history of the association showed a yearly increase in numbers, in influence and in financial standing. A large number of interesting reports and papers were presented, amongst the subjects discussed being the standard wire gauge, high insulation of electric light wires, the popular prejudice against electric light wires, reforms in the patent system, transmission of power by belting, electric motors, secondary generators, steam plants for electric lighting, converting the heat energy of coal into electrical energy, incandescent lights on high tension circuits, distribution by alternating currents, electrical engineering in Japan, &c. We hope to reproduce some of the more important papers and discussions. For the following we are indebted to the *Electrical World* of New York.

ELECTRIC MOTORS.

By WM. BAXTER, JR.

The rapidity with which the electric motor has reached its present state of perfection is without a parallel in the history of mechanical devices by which energy is derived from the forces of nature. The fact that the energy of gravitation could be utilised through the agency of water from streams descending to a lower level, was known to mankind in days prehistoric, and, as far back as the days of Archimedes, water-wheels more or less perfect were used extensively for industrial purposes; yet, it was not until modern times, when the turbine wheels of the present day were invented that gravitation motors were brought to a state of perfection. Even to-day, with all the refinements of modern engineering, it is considered a very superior achievement that a turbine wheel, constructed on the most approved principle, will utilise 90 per cent. of the power in the current that passes through it.

The steam engine (which most people suppose was born in the fertile brain of Jas. Watt) was known and used by the ancient Greeks, although in a very crude form. They utilised the power of steam to impart motion to toys and other unimportant purposes. Through all the centuries that intervened up to about 300 years ago, improvements were unimportant; from that time onward, however, the energy of heat through the agency of steam began to be used extensively for industrial purposes. Steam pumping engines of large proportions were made and operated in various parts of England for draining mines; but as they were very imperfect and costly in operation, they did not displace animal power to any very great extent. Improvements were made, however, from time to time, until Watt, by a master stroke of his genius, made the improvements which gave to the steam engine a position in the industrial ranks and placed it far beyond the competition of animal power.

The steam engine, however, to-day looked upon by most people as a perfect piece of mechanism, is not and can never be as perfect as the electric motor. Not because our knowledge of the laws which govern the action of a steam engine is less than that of the laws which govern the action of an electric motor, but because there is a principle in nature, "the law of latent heat," which renders it impossible for a steam engine to utilise more than a small proportion of the energy of heat contained in steam or the vapour of any other liquid.

From what I have just said, it will be observed that the human race has been familiar with water-wheels for at least 4,000 years, and that the steam engine was known in its crude form over 200 years ago. The electric motor cannot be said to have been known, even in its crudest form, much earlier than 50 years ago; yet, in the short period of its existence, it has developed to such an extent that to-day it is as perfect as the best water-wheel, and far more perfect than a steam engine ever can be. Furthermore, the laws of electrical science, in so far so they relate to the action of an electric motor, are so thoroughly understood that it is possible to obtain as perfect results to-day as is within the limits of possibility. And should the human race inhabit this globe to the end of time, it will never be possible to make a much more perfect motor than can be made to-day.

This statement may appear broad, but I venture to make it, and will explain why it is made. To those familiar with the laws of physics, there is no such thing as creating energy. All that can be done is to convert one form of energy into another. A given amount of energy in one form can never be made to give more than an equivalent amount of energy in any other form. To illustrate my meaning more clearly, I will say: An amount of heat energy the equivalent to one-horse-power cannot possibly be made to develop more than one horse-power of mechanical energy or work, even with a theoretically perfect steam engine. And one horse-power of electrical energy cannot be made to give more than one horse-power of work, even with a theoretically perfect motor. It is no more possible to create energy than to create matter. You may take a pound of putty and form it into any shape you please, but it is still one pound. You may roll it into a ball or draw it out into a string, it is the pound of putty still. So it is with energy. You may transform it from heat into electricity, from electricity into molecular or mass motion, and from motion back into heat, but you neither decrease nor increase it. There are men, however, who do not understand this fact, and believe that there is no limit to the power that can be obtained from a given electric current, and that, therefore, someone may at some future time discover some way by which 100 horse-power or more may be developed from the same amount of current that is now used to develop one horse-power. Any such result is beyond the limits of possibility or reason.

To-day we develop nine horse-power from an electrical energy of ten horse-power; one-tenth of the whole is all that is lost. Therefore, all that the future workers in the field can do, is to recover a part of this one-tenth. They cannot recover all, because there must necessarily be some loss.

Therefore, I believe I am within bounds in stating that it will never be possible to make a much more perfect motor than is made to-day.

A theoretically perfect motor would be one that converted all the electric energy passing through it into mechanical energy available outside of the machine. Practically such a result is impossible, for the reason that no mechanism can be made to run without friction, and no electric conductor—no matter how large—can be made without resistance; therefore, there must necessarily be a loss in friction and electrical resistance. This loss can be reduced a great deal, even beyond the point to which it is reduced in the perfect and practical motors of to-day. The only thing to limit the point to which these losses can be reduced, is the question of expense in construction. A motor can be made to convert $\frac{9}{10}$ths of the energy of the electrical current into power without going to any unreasonable expense; but it is doubtful whether the increased cost of construction necessary to attain a higher result would be compensated for by the additional gain in efficiency.

Now, it may be asked whether the electric motor—inasmuch as it is as perfect as man can make it—has reached a point where it is susceptible of every application which can be made of it at any time. To this, I would answer that it has not; that the applicability of the motor depends upon the cost of generating the current with which it is driven. The cheapest way in which an electric current can be generated at the present day is by the use of large dynamo machines driven by large steam engines of the most approved construction; and inasmuch as the best dynamos must lose something in converting the power of the steam engine into electric energy, and the motor also lose something in converting the electric energy of the current into dynamic energy, the power obtained by the motor must necessarily cost more than that developed by the original engine which generates the current.

Nevertheless, as large steam engines are much more economical in their action than small ones, and the cost of attendance is less in proportion to their size, it is possible to utilise the current generated by them to develop power in small quantities, at a cost low enough to compete with small engines. Up to just what point the cost of power so developed will be cheaper than steam cannot be stated with any degree of accuracy, because it depends upon a great many circumstances. In one locality, a motor up to 25 or 30, or perhaps 40 H.P., may be able to compete with a steam engine, whereas in some other locality under other conditions, a 50 H.P. motor may barely be able to do it.

If we were to take into consideration the absolute cost of generating power only, then electric motors of a great deal higher power would be able to compete with steam engines. But the electric current will be generated by electric light companies who conduct their business for a profit, and therefore the price which the user of the motors will have to pay for the electric energy he consumes will not be the net cost of developing that energy, but will be the net cost, increased by the profit which the electric light company desires to make. But, notwithstanding this increased cost occasioned by the desire of the electric light companies to make a profit, electric motors can compete successfully with steam in point of economy, and when convenience is considered, can compete not only with steam, but with any other method now employed for obtaining power in small quantities.

In all large cities and towns, people using steam engines rent surplus power to manufacturers in the same building or near by. In a great many cities there are establishments whose business is to run large engines for the purpose of letting out their power in small lots, the price of which is generally low enough to compete with small steam engines, and therefore these prices, as well as the amount of power let in individual cases, can be taken as a guide by electric lighting companies desiring to do business in the same district. If these concerns can make money at the prices fixed, electric lighting companies can make more, for the reason that the loss in transmitting power through shafting and belts is greater than the loss in transmitting it through electric motors.

In determining the cost of power, to consider simply the amount which is paid for it is not the only consideration, as many other expenses enter into the question. For instance, the rate of insurance on a building in which the work is of a hazardous nature will be very materially affected by the introduction of a steam boiler. This increase in the rate of insurance must be added to the cost of running a steam engine in comparing it with the cost of a motor to do the same work.

Again, in populous cities, and in busy portions thereof, space is of great value, and the difference in the amount of space which may be used by different kinds of motors employed should also be taken into consideration. Then, again, where a manufactory is located on the upper floors of buildings, and the lower part is

used for offices or stores, the jar, as well as the noise occasioned by the steam engine, would be such as to make the tenants object to its introduction; and on this account the proprietor of the building would demand a very much greater rent, so that, if this rent were added to the cost of the steam engine, it would be found that it would more than make up the difference between the actual or apparent cost and the cost of running the electric motor.

Besides the actual expense in dollars and cents, the question of convenience ought to be considered; because sometimes, although there may be no means of determining just what difference convenience may make, financially, it is nevertheless apparent to all, that it is worth while incurring additional expense, provided a proportionate increase in convenience is obtained.

The superiority of an electric motor over the steam engine in point of convenience is: First, that it takes up very much less room, makes much less noise, and is a very clean and simple machine which does not require a skilled mechanic to keep it in order. It does not have any stuffing boxes that have to be packed from time to time, which are liable to blow out at any time and fill the place with steam; neither does it have any steam pipes, which are likely to burst or spring a leak when least expected. There is no annoyance occasioned by carrying coal or removing ashes, neither is there the liability of injuring the work by soiling it, if the location of the building is such that it is necessary to carry the ashes or coal through a portion of the working rooms in or out of the building.

When we come to compare the conveniences of the electric motor with those of other hired power, we find that it possesses equally great advantages. If a man decides to hire power he must go into some section of the city where power can be obtained. He must content himself with rooms such as he can find, and it frequently happens these rooms are let out to any tenants that may come along, or may be in bad condition or cut up in such a way that it will require a considerable outlay to put them in a condition adapted to the business. On the other hand, if he buys a motor, he can select a building in any portion of the city that may suit him, and, after finding a building entirely to his liking, can locate the motor therein in any position in which it will be the most convenient, and simply notify the electric light company to introduce the wires.

It may occur to some that this is not strictly true, because he may select a building in a location far removed from the electric light mains; but this is altogether unlikely, for the reason that electric light companies run their wires through very nearly all the manufacturing districts of the towns in which they are located, and even if they did not have a wire running through the street in which he might locate himself, they would certainly run so close that they would be perfectly willing to extend their line to his place for the sake of the revenue to be derived from supplying his motor with current.

There is another way in which electric motors can be used, and in which they will be able to compete with steam engines of almost any size, and that is where the power of waterfalls can be utilised to drive the dynamos that generate the current. There are many places throughout the world where vast water-powers within 20 or 30 miles of large business centres are going to waste, where such plants could be established and made very profitable. The distance to which currents generated in this way could be carried profitably would depend very largely upon the extent of the water-power. If the supply be unlimited, the company could afford to lose even half the electric energy in transmitting the current to remote places, and still furnish it at such price as to monopolise the business of furnishing power. Therefore it may be said that the distance to which power could be transmitted in this way would range, say, from 10 to 100 miles, or even more.

In the foregoing remarks I have endeavoured to show the various ways in which electric motors may be employed at the present time. I have tried to point out the particular uses in which they will be found more economical, convenient, simple, durable, and reliable than any other means heretofore used.

In summing up the case I would simply add that the office of the electric motor at the present time is simply to develop power in small quantities and that it may also be used as a means of utilising the power of water-falls that may be within a reasonable distance of large manufacturing centres.

The field which the electric motor can fill at the present day is limited to the cases cited, because we have no means of generating electricity cheap enough to extend the sphere of its usefulness. The most economical way of generating an electric current at the present day is by the use of dynamo-electric machines, but inasmuch as these machines are driven by steam engines, and there is a loss in generating the current as well as a loss in reconverting it into power, it is simply impossible to generate the energy in the electric motor as economically as in the engine. If we were to use any of the electric batteries now known, the results would not be so good, for the reason that the cost of obtaining the current in this way is yet greater. There are batteries made which are decided improvements in point of economy over the batteries of former years, but they all generate the current by chemical decomposition of zinc, and so long as such means are used, the current generated can never be cheap enough to compete with a current generated by a dynamo machine, much less to enable a motor to develop power cheaper than a steam engine.

When a battery is invented in which the material consumed by chemical action is sufficiently cheap (say, for example, coal), motors run by the electric energy developed in such batteries will surpass steam engines in point of economy; but until then, they never can.

The cost of generating an electric current in a battery can be ascertained with extreme accuracy when the nature and cost of the material used is known. This is owing to the fact that in every case the current is generated by chemical action which takes place in the battery, and this chemical action, which is simply a form of motion, can only be made to develop an amount of electric energy which is proportional to it. A pound of zinc decomposed in a cell of an electric battery will develop a certain fixed amount of electric energy, regardless of the nature or construction of the battery or of the liquid used in it. Whether the amount of electric energy available from such a battery is more or less than that available from any other battery in which zinc is employed, will depend upon the perfection of its construction. But, assuming it to be theoretically perfect, the amount will never exceed that which would be the true dynamic equivalent of the energy due to the electrical action necessary to decompose the zinc. A pound of zinc will not develop as much energy as a pound of coal, and inasmuch as a pound of coal costs a great deal less than a pound of zinc, it will be seen that if a battery could be made to use coal instead of zinc, the cost of generating the current would be so much cheaper as to admit of no comparison. To make such a battery is not an impossibility. It may not be made for years to come, and yet it may be brought to the light of day when we least expect; but whenever it is made, or whenever a battery is made in which any other substance sufficiently cheap is subjected to chemical action, then the electric motor operated by the current of such batteries will develop power at a much lower cost than it is possible to do with a steam engine, and it will therefore take its place and be the power of the future, while the steam engine will occupy a prominent position in the curio halls of science, and will be pointed out to the children of future generations as one of the crude devices used by their benighted ancestors in days gone by.

DISCUSSION.

Prof. EDGERTON: In the paper we have just heard read, there is a suggestion which it seems to me should occupy the attention of the convention, and that is, in regard to the cost of supplying the electric current for motor purposes. What is wanted by our electricians and those who dispense and sell the current is to know whether there is going to be a large demand. If there is going to be a demand, and if it is to be permanent, I do not think there is one of you but will at once prepare for the work. Now, judging from the correspondence we have, and if we look over the field, I do not believe any man can shut his eyes to the fact that where one customer will use electric light, ten men—yes, a hundred men—will use electric power. The motor has also this advantage as to permanency. The electric light is to all intents and purposes a luxury. Your business man, as soon as trade falls off, says, "Take my lights out, I am done with them for the present; I can get along with gas for the time being." If he can't get gas, he can get something else. But when you take a motor and put it into a man's place and put money into his pocket, and give him something which is better for him, you have got that man's business as long as it continues. For that reason, I think, the electric light companies have the prospect of a large new business with a royal percentage of profit coming in. I want to suggest that this convention appoint a committee to take in hand the matter of the price of furnishing current by the electric light people, and to prepare a list or scale of prices that would be mutually satisfactory, the committee to offer it at our next meeting.

Mr. DECAMP thought the suggestion a good one, and stated that the price they were getting for motor service in Philadelphia was 65 per cent. of that for electric light. They had no definite data to go on, but were charging at the rate of $5 per month for four small sewing machine motors.

Mr. DUNCAN said he had had some little experience in the distribution of power with motors. They were running in Pittsburgh altogether sixteen motors varying in size from a half to ten-horse power. These motors were all running with one exception upon the direct incandescent current. The question as to the relative cost of light service and power service was not sufficiently advanced for definite and equitable settlement. He had no hesitation in stating for the information of the association that he could obtain from the distribution of power twice as much as he could for light. They had no difficulty in placing these motors at all. The demand came to them, They did not go after it. Furthermore, the satisfaction obtained was such that they had on record in their office statements to this effect; parties who have used these motors for six months, as against steam or gas power, would be willing to pay 25 per cent. more for the electric service. Of course, that was gratuitous on their part, for he should certainly ask them next year to step up instead of down. As regarded the maintenance of motors, and the amount of service required to keep them in order, he would say that as far as he could see, and as compared with an arc system, the motor requires no particular attention at all. An arc light did require particular attention, and from his experience he would say that the carbon trimmer, after a little training of a week with a motor in the shop, could, if he were at all a competent man, make a round to all the motors in service and keep them running. In Pittsburgh they simply made a round twice a week to every motor in service. The man made a report. It formed part of his duties the same as his carbon setting and the report on his lamps. He

could not see why, where a light station was properly equipped for doing business, there should be any increase of force or attendance necessary, whatever, for the distribution of power, say, up to 100 motors in service. That was, where the district was already covered by the light wires. Outside of that, it was a matter of development, the same as anything else. He thought it had arrived at that point where they could safely say that in large cities the distribution of power by means of electricity was one that would pay to run either as a separate plant or in connection with the lighting business. It was simply a question whether the lighting people were going to keep that business to themselves, or whether they were going to allow somebody else to step in and take it as a separate business. In regard to the amount of investment and the relative cost, after they had placed four or five motors they arrived at the conclusion that it would be a very good thing for the customer to buy the motor—in other words, it would be a very good thing to have the customer interested in the business. So far, the majority of the motors were owned by the subscribers.

Mr. MORRISON said that they were all aware that in large cities the efforts of the local authorities had been in the direction of encouraging small industries, by taking off taxes, giving them free water, and so on. From one end of the land to the other the effort was being made thus to stimulate small manufactures. But one of the principal drawbacks was the impossibility of having steam power so arranged as to be distributed in localities where rentals were cheap, and where there were facilities for men with small capital—shoe-makers, tailors, small machine-shops, box-makers. A thousand and one such industries can be carried on, and would be carried on, with profit, and with benefit to the community, if it were possible to furnish the power to run the machinery for the work. Furnishing a steam plant and renting out steam power was attended with many difficulties, beginning first with the placing of the boilers, which were very often objectionable to owners of property adjoining. One way of meeting the difficulty had been found in concentrating a number of trades in one building owned by the man who controlled the steam plant. The rentals were therefore under his control, and he fixed them so as to make his investment a paying one. But it was not a paying matter for the man who wanted to run a small shop on the fourth or fifth floor, and he was practically shut out from the prosecution of his trade for himself. Hence the aim of such municipal legislation was virtually defeated at the outset. You could not distribute steam power efficiently and cheaply over a large district. That question was settled. But now let them take the electric light companies who already had their wires stretched all over the various cities of the Union. Recent statistics had shown to what extent the arc and incandescent light was being used, and how there was thus, almost at the door of every man, the facility for using electricity as a motive power for whatever small industry he might be engaged in. That being the case, and looking at it from the other side, it had been said that if they had 1,000 horse-power they could sell 2,000 horse-power on a varied service and have absolute security. At any rate, he believed they could use a very large proportion above the actual capacity, where they had to utilise power intermittently, and to such an extent as to much more than compensate for the difference mentioned before between lamp and motor prices. He did not know any lighting company whose contracts outside of municipal would average more than 60 days in the year—except at Philadelphia. Taking the average, they would say 90 days. The balance of the time they had three-fourths of their plant idle. They had to equip to supply a maximum demand. Now, then, if they made a contract for power, they made it from one year's end to the other. That was the case so far as concerned Baltimore. That was the promise given there, that they made their contracts by the year and the rate of charges was governed by the rate of charge for steam per horse-power. It did not require the gift of prophecy to foretell what would be the result of that sort of business. For three or four years they had been waiting for the motor to come along. If the proper motor had now been presented to the public, that part of the question was settled, and in the next twelve months or two years they would find a very remarkable addition to their service and a very pleasant addition to their profits if they chose to introduce the motor. It was a question as to whether to do this was good policy for an electric light company. There were always troubles with divided responsibility. He was not himself quite determined on that point. It might perhaps result in the formation of a motor company to do the motor business, making a contract with the electric light company for its current. That would make those operating the motors responsible for the motor service, and at the same time relieve the electric light company of additional expenses. On the other hand, the motor company would be relieved of power plant expense. That was the way the idea suggested itself to him, and all these points must be considered. He did not think that any of them had gone sufficiently into the question to settle it just yet one way or the other, as to whether or not the motor business was desirable simply as an adjunct to the lighting business. He did not believe it could be solved in any way except by practical work. The nearest thing to practical work was the report of Mr. Duncan, who stood in his place and told them the result had been a profit to his company. Mr. Duncan was a living witness to the profit and benefit of the motor business for an electric light company. Altogether, from the present outlook, he believed that the report of investigators in that field would be in favour of motors as a proper and profitable method of power distribution.

Mr. UPTON reminded the convention that 18 months before he had, in New York, urged on them that very point. In Boston, the motor subject had been satisfactorily taken up and dealt with. The Edison station there had 300 horse-power, and one-third was now used in transmitting power electrically. It had proved a valuable addition to the economy of that station, much larger than they could possibly conceive. He believed that all central lighting stations should put in motors. The additional cost was small, in some cases running all the time it was simply the cost of the coal used, with possibly the wages of a few inspectors. In fact, the whole question had been satisfactorily settled in Boston, where they were running elevators two miles from the station, both passenger and freight, with most perfect success.

Mr. HARDING stated that in Boston they were getting $125 per horse-power per year for a day of 10 hours. They preferred the contract system as the only sensible one to use with the supply of intermittent power. Another point he would insist on strongly was to sell the motors and not to rent them. They had sold every motor they had put out in the city of Boston. As a result, the customer took excellent care of the motor. When the motor was placed in a shop, a good reliable man was selected to take charge of it there, fill the oil cups, start it in the morning, &c. Then they had an inspector who went round at certain intervals to see that everything was all right. Another point was, not to have the motor overloaded. In Boston with about 40 or 50 motors they were deriving an income which was paying the local Edison company on its total original capital of $100,000, eight per cent. from power alone. Every day men were coming to the motor company wanting to buy motors. The motors were now called for in very much larger sizes, at present more 10 H.P. than any others, but 15 and 20 were in demand. These motors had a guaranteed efficiency of 90 per cent., and the power was guaranteed. In one case, where a motor had been overlooked, it ran for seven weeks without inspection or attention, but he advised systematic inspection, which would only take one minute in each case. As regarded elevators, there was certainly nothing in machinery, say, up to 20 horse-power, that the motor would not do. They were now running the largest elevator in Boston, a freight elevator 12 feet long, 6 feet across, going 60 feet a minute. They were also running a passenger elevator going 100 feet a minute, and both were run from the same motor of about 15 horse-power. He thought it desirable to have data collected as to power required, &c. As to fuel, in Boston they were burning cheap fuel, three tons of screening, costing about $2, and one ton of Cumberland, mixed, costing altogether delivered, about $2.50 a ton. They used the Jarvis setting, and from that got excellent results. A large proportion of the business was elevator work in the wholesale part of the city. About half-past four it was almost entirely deserted, and so the power business began to go off as the lighting came on. It would be different in different cities. They were not using one quarter of the current they could obtain from the station. The circuit upon which motors were running in the day ran lights also.

Mr. MORRISON: That is the secret. Nearly every station is now running a day circuit which is not loaded to its full capacity.

Mr. KERR held that only when the incandescent wires embraced the residence portion of a city would they be able to sell much beyond their actual capacity. For instance, in one town where the total call for incandescents would be 7,000 lights, the business portion took only 400 lights. Now, when they got the 7,000 lights, including the big residential area, they could rent power or light far above the station capacity. Companies that went out into residence districts found that they did not have to increase their stations so rapidly as their rented capacity would indicate. He knew stations in this way running 1,300, 1,400 and 1,500 lights from two 500 light machines, because there, if a man went to the church, theatre, or hall, he didn't burn his light at home, and if all the lights were going in one house, it was because a party was going on there while all the lights in the neighbouring houses were turned off, the people being at the party.

Mr. DUNCAN and Mr. KERR agreed that as for instance in Pittsburgh, 33 per cent. might be figured on as the excess margin that could be contracted for.

Mr. GARRATT took exception to Mr. Baxter's point as to the greater cost of zinc as a fuel than coal. A good engine would not show at the pulley more than 13 per cent. of the energy in the coal burned under the boiler, so that the difference was not so great as might appear. While no man in his senses would claim that zinc was a cheaper fuel than coal to burn, there were occasions when zinc had a special use and place. He instanced a case in Boston where he furnished a motor with battery for a store. He had charged the parties a good rate for it, but they sent back, wanted to know the price for the whole, and bought it outright. Evidently there was a use for zinc as fuel.

Mr. R. T. MCDONALD: One thing I want to call attention to in connection with motors. We are all in the electric lighting business to make money, and the tendency in lighting has been to get prices too low. I understand it is proposed to appoint a committee to fix prices which are to be charged for motor service, and in that connection something has been said in regard to the proportion of motor rates to light rates. My experience is that the price of lights varies very considerably all over the country. In some places these rates are fair, in others ruinously low. Now the motor price ought not to be considered in that way. The price to be charged for motors ought to be on the basis of the cost of coal, instead of the rates charged for light. I think it is a growing business, and it will not be long before the

majority of the electric light companies will be using motors. It is highly important therefore for them to start out on a basis that will pay them. It is easy to go down on price, and hard to get up.

Mr. DECAMP stated that they rented one man five motors and charged him, as usual, $6 for them. They rented another man ten motors and charged him $11. The man with the ten motors gave up business or moved, and sold them to the man with five. That man threw them all in together, and thus ran them a couple of months, paying $6 for the service of the fifteen. That was perhaps to be met by cutting out automatically when any excess was thus taken.

Mr. R. W. POPE: That difficulty was obviated by the Gold and Stock Telegraph Company, in New York, originally by charging the subscriber $100 for installing the instrument. It was understood in the lease that this did not give him the ownership of the machine. He had the privilege of having the machine, but if he gave up business he could not take the machine with him. The company retained the machine, also the hundred dollars. The original subscriber retained his privilege of leasing the machine. If he could find another party desirous of taking the machine, he could make a "dicker" with him. It was practical ownership, but the company thus controlled the property at all times.

Mr. WEISSLEDER read the following interesting letter:—

Brush Electric Light Co.,
Detroit, Mich., *Feb. 3rd*, 1887.

Brush Electric Company, Cleveland, Ohio:

Gentlemen,—I thought it would be of interest to you to hear a report from your No. 4 six horse-power motor recently erected by us.

We put it into Raynor's printing establishment in this city, and connected it with our regular arc light circuit. It takes the place of a 10 H.P. engine, which was formerly employed, and which sometimes stalled under its load. It runs about 70 to 80 feet of shafting; it drives right along on the first floor three cylinder presses, four platen presses, one large steam paper cutter and one very heavy freight elevator. Power is then transmitted by a 4-inch belt up through three floors and there drives three ruling machines and four paper cutters.

It does its work splendidly, and its motion is steady and regular. The proprietor informed me this morning, after some ten days' use, that it worked splendidly, and that printing offices and others could well afford to employ it instead of steam, even though it might cost more.

We are having very many inquiries for these motors just now, and I find that Mr. Raynor takes pleasure in extolling the merits of his motor to all visitors and inquirers.

Yours very truly, WELLS W. LEGGETT, *President*.

Mr. F. J. SPRAGUE, of New York, said: The time has come for us to look upon the distribution of power in a light altogether different from that in which it was viewed three years or even one year ago. We have heard about electric motors, and we have talked about the possibilities of the transmission of power ever since Pacinotti ran his first motor. But motors were run primarily with batteries, and it is only recently that they have been operated in connection with central stations.

They have been made of small sizes and treated as toys, and more batteries and motors have been invented than there have been made variations in the steam engine, but we have never reached any position from which we could show a commercial return from the use of electric motors until the last year or two.

The distribution of power by electricity, so long looked upon as a visionary and to-be-hoped-for attainment, is now an accomplished fact. It is in its infancy, but it has a future probably second to no other enterprise in the commercial world. It is not necessary here to give a scientific explanation of the operation of a motor. I will try to briefly show that electricity will fill the field in a far more complete and satisfactory manner than, but in very much the same general way as, does the distribution of power from a central station by means of gas, steam, water or compressed air. The use of any of these elements for this purpose is an engineering problem. To be successfully solved, not alone scientifically, but commercially, every part of such system must be in thorough accord with every other part. It is not enough that there shall be a good dynamo, or that there shall be a good motor, but that the dynamos and motors shall be built for certain specific electromotive forces definitely related to each other, and that the conductors should be put in for the distribution of given amounts of energy to the motors, under given losses, and the motors should have an efficiency that is not visionary or sought after, but which is just as well known as the characteristics of any part of the system.

In considering this question, however, we are confronted with grave responsibilities and many difficulties, and those who assume to advise the general public cannot be too careful of their utterances. We have to consider the state of the art and the people's knowledge on the subject. We have even to contend against the ignorance of people in charge of central stations, and we have to contend against a much worse element, the ignorance of the general public concerning electricity. With steam we do not have to deal with this difficulty at all. Trained and experienced engineers can be secured without number. They can be hired by the week or month to care for an engine, and since all engines are based upon nearly the same principles, and are practically alike in their operation, no difficulty is experienced in getting good men to care for a five, twenty-five, fifty or a hundred horse-power engine. This is not the case with electric motors. We are obliged to depend upon the central station managers and those whom they especially train.

The practical questions which arise are: Who are to exploit this business? Who are to be actively interested in the extension of this system for the transmission of power?

There are two representative industries already in the field. The first to come was the arc light; then the incandescent light; and now, finally, comes the transmission of power for industrial purposes. There have, in consequence of the order of development of these three different methods of using electricity generated at a central station, arisen three different companies, more or less antagonistic to each other, but which ought to be working in harmony.

No one can doubt that if, ten years ago, the arc light in its present stage of development, the incandescent light in its present perfection, and the electric motor as efficient as it is to-day, were all three at the same time presented to capitalists as commercial investments, all three would have been taken up by the same men on a broad, comprehensive plan, and each would have held its own particular field, and would have been pushed with the same energy and success that they have been individually; and that, instead of there being more or less of a rivalry between these three branches of industry, they would have been operated under one control, one general expense, and one profit.

An illustration of their natural unity of interest is afforded by the action of the various companies representing these different branches. Arc light companies are operating incandescent light; incandescent light companies are running arc circuits; both are beginning to use motors; and I suppose some of the future motor companies may be rash enough to supply lights.

But since we have to deal with existing conditions, and vested rights and privileges, let us briefly consider the various organisations which can be instrumental in developing this new field of work, and the methods by which they may be successful. As being in the position to actively take up this work, I may mention, first, arc light companies.

A very large number of existing companies have already secured free franchises which it would be difficult for other companies to obtain. Some of these companies are to-day just barely meeting their running expenses, because they are supplying power for lights for only a fraction of the day or night in close competition with the gas interests, and perhaps with other electric light companies. As the demand for light varies, of course, at different times of the year, the receipts vary above and below the operating expenses. All through the day, till perhaps five in the afternoon, these stations lie idle. Such companies have their poles erected, their lines run, and certain franchises in their possession, and it would be an easy matter for these same companies to run lines for the distribution of power on the same poles as carry their arc light circuits. The wiring for this purpose would be very simple. In some cases the poles would have to be reinforced; in others it would not be so. For running these lines to supply power alone, constant potentials as high as 400 volts could be used with perfect safety, and this would very much reduce the size of the wire.

As regards incandescent light stations, many of these run only in the daytime, and do not begin their lighting until late in the afternoon. The bulk of their lighting terminates long before midnight. Other of these stations run during the day because they find the necessity of supplying a few lights in the daytime to get certain contracts for night work, but almost invariably this day work is at a loss. These companies already have their lines run to supply power on constant potential circuits, some overhead and others underground. Since the power would begin in the morning, and continue for a general average till the latter part of the afternoon, and then begin to fall off, and the light at the same time begin to come on, such a station, if worked up to its full capacity, ought to have an almost continuous load from morning until late at night; the load consisting first almost entirely of power, then of light and power combined, and finally, almost entirely of light.

The gas engine, although it has made great strides in England, does not stand in high favour to-day in the United States. A gas engine will not work up to the capacity at which it is sold and at which it is nominally rated. It will fall off anywhere from 25 to 50 per cent. below this. Its motion is necessarily irregular and uncertain, because during a large part of its rotation it is dependent upon the inertia of the fly-wheel. Such machines are necessarily more costly than electric motors of the same capacity, such cost being about double. They are noisy, they cause a great deal of heat, and they are uncertain. Their advance in England was made before electric motors were as practical as they are to-day, and where gas is sold at a very much lower rate than it will be possible to get it for in the United States for many years to come. The electric motor, then, can easily compete against the gas engine when put side by side, both in initial cost and expense of operation. It is likewise more compact and has an excess capacity, a quality that is never claimed for a gas engine. Gasworks have among their residual products coke, which is of very little value. By putting in good generators, running wires for the supply of power alone, and putting the generators and dynamos in charge of the men who are already employed at the gasworks, they could produce their power and sell it at a very advantageous price. Their office rent, officials' salaries and attendance would be reduced to a minimum.

Special stations should be put in good manufacturing and industrial districts, and preparations made to supply any demand for power from a half horse-power up to 100 or more horse-power. There is no possible question that, when a large number of

motors are supplied from one district, even when dealing with large powers, electricity can successfully compete against steam.

Double circuits can be used, small powers being supplied at 100 volts and large ones at 400. Such stations should be built to get the steam power at the lowest cost, and hence should have the best engine and the best method of fuel consumption. The district covered will depend upon the location of the station. If this is central, two or four square miles can be easily covered.

I will now consider the different classes of circuits on which motors may be used.

First. Arc light, or constant current circuits, in which the current supplied to the motor is kept constant at a certain number of ampères, ranging from six to nineteen ampères in different systems. The electromotive force at the terminals of the motor varies with the load.

Second. Constant potential, or incandescent light circuits, in which the difference of potential at the terminals of the machines is kept practically constant while the current varies with the load.

Third. Circuits in which the current and the potential both vary, as is the case where there is an appreciable drop or fall of potential on connecting lines somewhat removed from the source of power of a constant potential system.

I am now operating on all classes of these circuits, but since, because of the small ampère capacity of the current on arc light circuits, any large power must require a great difference of potential at the motor terminals, and variations of power will cause sudden and great changes of potential, the arc light circuits have principally been used in conjunction with arc lights for transmission of small powers only, or for constant work.

In considering the transmission of power as an industry, that is, in a broad and comprehensive way, and not as an adjunct to some system of lighting, I may here state that practical and theoretical considerations make it imperative that the constant potential method of distribution is the only safe and feasible one. Since I make this statement, it is incumbent upon me to explain the reasons. The only existing constant current circuits are used primarily for the operation of arc lights. At present, as I have said, these range in capacity from nineteen to six ampères. The unit of light which is required for general purposes necessitates an expenditure of about half a horse-power of electrical energy. A greater expenditure would be extravagant. In order to keep the size of the conductors as small as possible, and to allow long extended circuits, the tendency is to reduce the ampères to the smallest number.

The conditions of an arc light probably will not allow this to go below about six ampères; the more ordinary unit is about nine and a-half. The commercial conditions unquestionably will not permit, in the future, of a much higher ampère capacity, because the size of the wire varies as the square of the current used. Now, with a nine and a-half ampère current, a motor to develop one horse-power—supposing it to have an efficiency of eighty per cent.—must have supplied to its terminals 933 watts of electrical energy. In other words, there would be at the terminals of the machine an electromotive force of about 98 volts for each horse-power developed. Suppose, now, we want to transmit one hundred horse-power; it would then be necessary (if the motor be of the same efficiency) to supply to the motor 93,250 watts of electrical energy; and, if it were on this 9½ ampère circuit, we would have an electromotive force of over 9,800 volts.

Now, in practice, arc light circuits vary from, say, 1,000 to 2,500 volts. On a 1,000-volt circuit you could recover about ten horse-power; on a 2,500-volt circuit about twenty-five horse-power. In other words, existing arc light machines, if devoted entirely to the transmission of power, are limited to the actual development, on even the largest machines in ordinary use, of twenty-five horse-power; and, if used in combination with light, there would not be available on any particular circuit over a small fraction of this. Now, if you are going to consider motors as toys, if you are going to deal with the transmission of the tenth of a horse-power, or one-half horse-power, or a one horse-power unit, and are willing to have the element of danger as well, enter into these small transmissions, then you can work with an arc light circuit; but if you are going to transmit units of five, ten, fifteen, twenty, or twenty-five horse-power, you cannot deal with the arc light circuit; it is utterly impossible.

In Boston we have recently put upon certain lines nearly two hundred horse-power. Suppose this were supplied on 9½ ampère circuits. No less than eight circuits of 2,500 volts each would be required, and probably more, because with units as high as fifteen horse-power and this division of circuits, the law of general average could come into play in but a very limited way.

These eight 2,500-volt circuits represent the capacity of a 460 arc lamp station, and to deliver the power not a single lamp could be used at the same time. Does anyone really suppose that by this method of working, leaving out for the present all question of danger and unreliability, the same results could be obtained as are in fact to-day? The constant current method of distributing power is the limited and unnatural method; the constant potential, the comprehensive and natural method. This is a fact entirely independent of the question of relative electrical potentials, because on the constant potential circuit we can work at 100, 500, 1,000 or 2,000 volts if we please.

In Boston we at present transmit up to 4,800 feet on a 200-volt circuit.

When dealing with the question of power alone, and with an area of, say, four square miles, the station being near the centre, I would prefer to work with 400 volts. Remember then, that power transmitted means the transference of a given number of watts of energy. It is expressed by two products, quantity and pressure. If one is increased, the other may be reduced. If small conductors are to be used, then it is essential that small currents shall be used, and of necessity high electromotive forces, even when operating on a constant potential circuit.

When dealing with short distances and small powers it is better to use low potentials; but when dealing with large powers and long distances it is absolutely necessary to use high potentials, because the commercial conditions will allow only a certain proportionate investment in copper. There are certain laws to which it is well to call your attention, as they may serve to make more clear some of the questions which come to you.

First, with any given work done by a motor, loss of power on the lines, electromotive force at the terminals of the motor, and distribution, the weight of copper varies as the square of the distance. That is, if the distance is doubled with these given conditions four times the weight of copper will be required.

Second, with the same conditions, the weight will vary inversely as the square of the electromotive force used at the motor. That is, if using double the electromotive force at the motor, it is necessary to use only one-quarter of the weight of wire. Another way of expressing this is, that if the weight of copper is fixed, then, with any given amount of power transmitted and a given loss in distribution, the distance over which the power can be transmitted can be increased in directly the same ratio as is the electromotive force; for example, if a thousand pounds of copper is required to transmit a given amount of power with a given loss, and it is desired to double the distance with the same weight of copper, then the electromotive force must be doubled. Again, with the same cross section of conductor, the distance over which a given amount of power can be transmitted will vary as the square of the electromotive force. Another way of expressing these laws is by means of a formula which I have been using for a long time, and which you will find of service in determining the size of wire to use in the transmission of power. Let

l = distance between the generating and receiving stations in feet.

n = number of effective horse-power to be delivered on the motor shaft.

E = electromotive force at the terminals of the motor.

v = number of volts fall of potential on the line.

$E + v$ being, of course, the electromotive force at the beginning of the line.

K = efficiency of the motor.

C M = circular mils of conductor.

Then, allowing 10·5 ohms as the resistance of a mil-foot of commercial copper, and considering a complete metallic circuit, we have

$$\text{C M} = \frac{15{,}666 \times n \times l}{E \times v \times K}$$

Let me give you a practical illustration. Suppose we have a motor, the efficiency of which is 90 per cent. at 400 volts electromotive force and when developing 10 horse-power, and that we wish to transmit this 10 horse-power 5,000 feet from a station, and elect to lose about 9 per cent. on the line.

Our initial electromotive force will be 440 volts, and we would have

$$\text{C M} = \frac{15{,}6\,6 \times 10 \times 5{,}000}{400 \times 40 \times \cdot 90}\text{ ; or,}$$

C M = 54,396, which is about equal to a No. 4 B.W.G.

This electromotive force of 400 volts is a very good standard. Without serious inconvenience we can go to 600. For long distance special transmission it is necessary to go up to 3,000 or 4,000. If the arc light current be used, all motor handlers take the risk of high potentials.

As I have already said, you have to contend against the ignorance of people using motors. It has been said that you can put a motor on an arc light circuit, and it will take care of itself; that the people at the central station will take care of it. This is true to a certain extent and to an equal extent it is not. I came very near having a serious accident in New York. I was working on a Brush circuit of 2,500 volts. I took hold of the motor and began to adjust the brushes, at first unintentionally, and finally intentionally; but it so happened that I was not in a position to be grounded. Had I been so and there had been a ground on the line some distance away, there would have been an end to my motor experiments. A similar end would have resulted if I had lifted the brushes. We put in an automatic cut-out to avoid that danger. We found that a man blocked the cut-out so that it would not work. If that motor and cut-out had any trouble with it (it was on one of the most important Brush circuits in New York, one 15 miles long) it would have caused the blocking of the entire line.

With a constant potential circuit this kind of trouble is practically impossible. If there are grounds anywhere on the line, or any defects in the motors, they will cut themselves out of circuit automatically, and the rest of the circuit is not affected.

Mr. SPRAGUE here stated that he would be glad to answer any questions members of the convention might ask, because in that way perhaps he would confine himself to what would be of most pertinent interest.

Dr. MOSES: Will you be so kind as to tell us something about the cost of motive power?

Mr. SPRAGUE: It is plain that in New York City the New York Steam Company is furnishing power to 435 engines. That power is supplied from a big steam station in Greenwich Street. The conductors or pipes used for conveying the steam are, of course, of very large dimensions. The steam when delivered to the engine is wet steam, and the pressure is about 80 or possibly 90 pounds. There is one point of great advantage in the electrical transmission of power, in that you can work at so much higher electrical pressure than you can steam pressure. Then, again, the cost of conductors for electrical transmission is very much less than the cost of conductors for the transmission of steam, and you have not the objectionable element of wet steam. Yet here is the fact that the steam company is furnishing 435 engines with power and is making money. The consumers find it cheaper than they can generate their own steam. We found it necessary in dealing with the various light companies to have certain facts in our possession as to what we could do if we had 500 or 1,000 horse-power in a central station, as to how much power we could contract to deliver, and how much could we get for it. The manager of the Edison Central Station, in Pearl Street, New York, insisted that the meter was the proper means of determining what must be paid for power. If a man uses his motor, the meter registers against him. This was done on our motors. He charged $1\frac{3}{4}$ cents per ampère hour, and he thought he was going to have a bonanza. And so he would have had if the motors had not been automatic. After four or five months' running, we went to these people and asked them to let us see copies of their bills. We found some curious facts. I will cite one instance as showing the economy of the transmission of power by electricity:—There is a firm of chemical dealers, James L. Morgan & Co., No. 47, Fulton Street, New York, who are running a freight elevator. They have a 3 horse-power motor working up to $4\frac{1}{2}$ horse-power capacity. Their bills average about $12.50 a month; that is $150 per year. Had that motor been used, not up to $4\frac{1}{2}$ horse-power capacity, but simply to its normal capacity of 3 horse-power, steadily ten hours a day, their bills would have been about $1,200 a year. So you see the average percentage of the time for which they use the motor is less than 15 per cent. There you have an example of a motor, the people using it as they please, as many hours a day as they please, and they find by their meter bills that they only use that motor to 15 per cent. of its capacity. Now, we took a great many of these cases, printing offices and burnishing machines, &c., sometimes where they ran continuously and where we knew the machine was oftentimes overloaded, and we found this simple fact, viz., that with the whole capacity of motors, they average not over 33 per cent. of their capacity. In no case did we find, where they used the motor without any let up, that their bill was more than 51 per cent. of the capacity of the motor.

Mr. DE CAMP: Will you allow me to ask you as to the distribution of the business? Was it distributed among the class of people making up the general community.

Mr. SPRAGUE: Yes, sir.

Mr. DE CAMP: How many users did it cover?

Mr. SPRAGUE: I do not know; but it is a thing which holds, no matter how many we take. We took specimen classes of work, that is, elevators and burnishing machines, and work of that kind. All our records, however, go to show that motors, as a rule, do not average over 33 per cent. of their capacity for the 10 hours of a working day. This, in fact, is a large average. This may to a great extent be understood from the following statements: A motor is absolutely automatic. The total current used in machines of the high efficiency which we make is almost directly proportional to the work done at any instant. The result is that if the work slacks for a moment so also does the current. Almost all work is spasmodic in character. Motors have to be put in for their maximum capacity, but not one class of work out of a hundred, with the exception of ventilation, offers continuous duty. Some motors are stopped, and in others which are running the work is constantly varying from the maximum to the minimum. An illustration of this may be cited in the case of elevators. If 20 elevators, each requiring a maximum of five horse-power, were driven from the same line of counter-shafting, they would not require an engine of over 40 horse-power, because some would be going up, some going down, others standing still, and in not two cases out of the 20 would simultaneous trips be made, while in not one trip in 500 would an elevator be hoisting its maximum load from the basement to the loft. Comparison also may be made with existing incandescent light plants. Practical experience shows that not over 55 or 60 per cent. of the total number of lights in use in a station are used at any one time, although it is possible to use them all. But incandescent lamps when they are in use take their full amount of current. Not so with motors. A certain percentage of the motors, just as with the lights, would not be in use at all, and in most of those in use the current would be continually varying, just as if the lights of an incandescent light station were being turned up and down from 1 to 16 candle-power, as well as many of them being turned out. The recovery in an ordinary district with 88 to 90 per cent. of the power delivered to the dynamo pulleys converted into electricity on the line and 10 per cent. loss in distribution is about 65 per cent. This 65 per cent., however, where the work is distributed, is only 33 per cent. of the capacity of the motors for which power can be contracted. In other words, for every 100 horse-power in a central station, 65 horse-power at any one instant can be delivered under an ordinary distribution, and this 65 per cent. is only one-third of the power which can be contracted for provided there are a large number of motors in use. Of course where only one motor can be used, then 65 horse-power only would be obtained, but the object of the central station is to take advantage of all the falling off of work, and that it can be done is shown by the records which we have of a large number of motors in use. The question, then, for central station managers is not how much can they afford to supply one, two or twenty horse-power in a single instance, assuming that to be the only power delivered; but for how much they can afford to deliver power provided the full capacity of a certain engine is taken up by a number of motors. The introduction of the electrical transmission of power into Boston was accomplished by the personal efforts of the president of our company, myself and our agents. The Boston company were not required to take any steps except to run their wires. We agreed to pay them $125 a horse-power per year—a pretty good price for us to make a contract for. The steam power actually costs the company about $30 to $35. Mr. Harding, then our New England agent, and now our general agent, started out to rent motors, charging $150 a year for horse-power. He pretty soon made up his mind that he would *sell* the motors. Every one put in during the past three months has been sold. In that one station there are nearly 50 people owning motors varying from $\frac{1}{4}$ to 15 horse-power. That shows we have passed the experimental stage. We are no longer dealing with toys or theories. We are dealing with the commercial exploitation of the transmission of power. In New York City we are going to introduce motors to run the largest Hoe printing presses. We are going to prove that in dealing with these large powers we can do it more economically than it can be done by steam engines.

Mr. DE CAMP: Do I understand that in case I had 100 horse-power in my mill it could be furnished cheaper from an electric motor than it can be furnished by steam?

Mr. SPRAGUE: Yes, if you are running in connection with a central station. Large engines can be operated and large powers developed under as little general supervision as smaller powers, and under far less supervision than several units of smaller powers. The cost of such generation of power is much less in larger engines, both in the amount of coal and water used and in the matter of attendance, and also in the general expense. It follows, then, that if the power of a manufacturing district can be centralised, it can be developed at a much higher efficiency and at a very much lower cost than where it is being generated in a large number of units. If, now, this power can be sent out or distributed to a large number of users in the district, then, supposing that only the same amount of power is sold as is generated in the central station, this plan of generating power would still have the advantage in point of economy. But when it is taken into account, as has been shown, that where power is distributed to a large number of users from a central station, this station can take advantage of the very large falling off in the use of machines, it at once becomes apparent that if the system is properly constructed and operated, there is not only not a loss, but a great gain, in the centralisation of steam power, and this will hold true whether dealing with a central station of 100 or 10,000 horse-power.

A MEMBER: Mr. Sprague, what about the question of heating mills?

Mr. SPRAGUE: Mills are not obliged to use exhaust steam; there are several other ways of heating them. I am not advertising any particular method.

Mr. RIDLON: Mr. Sprague, do you think it is possible with a water power of 700 horses that is a mile away from a mill to generate 150 or 200 horse-power as cheaply as by steam?

Mr. SPRAGUE: Yes. Of course the original investment would be more, because you would have to put in a generating station. Water power is not the most reliable thing in the world; I would rather depend upon steam. It is a question of cheap fuel. Get as much money for power with the least possible expenditure. Water power is all right provided you have plenty of it. I am going to start a central station in New York (provided the three-headed Commission we have there will allow me) of 500 or 600 horse-power and working at 400 volts electromotive force, and then you will see the truth of what I tell you.

Mr. RHODES: Is it possible to transmit water power to a distance, say, of 10, 15 or 25 miles?

Mr. SPRAGUE: Yes, sir. There is this element to consider in the transmission of power; it is just as practical a question as the transmission of energy by any other means. The moment that the interest on your plant and the depreciation and the cost of operating exceed or equal the cost of production in the central station, just that moment do you want to drop the transmission of power. That is, in other words, if you want to go from A to B, and that is a distance, say, of two miles, you can transmit that at a certain pressure and a given investment. If you want to go ten miles, then the question comes in, will my investment and the depreciation cost me more than if I generated my power at that point, no matter whether it is by steam or water. I know there is a great deal of talk about transmitting the power of Niagara Falls to New York City. It never will be done in this wide world. The transmission of power even ten miles will not pay except in special cases, as coal is too cheap. I am just as practical on that question as any man can wish me to be. As an instance of the tremendous field which opens for special work, I will mention one case in which we have submitted an estimate for transmitting 200 horse-power over 16 miles, and we have been asked to consider, also, a proposition for transmitting 600 horse-power 22 miles. In these cases the investment, of course, is very large. It is necessary to work with very high electromotive forces; but as to the commercial value of such trans-

mission, you may judge from these facts: In the case where the 200 horse-power is desired to be transmitted 16 miles they are now operating a 100 horse-power engine to supply power in three or four levels down in the mine. They do not receive over 40 to 45 horse-power. Coal of a poor quality costs about $22 a ton, and wood costs $11 a cord. It costs about $150 a day of 24 hours to operate this 100 horse-power engine from which only 40 horse-power is received. Sixteen miles away an ample water-power is found in a river running down the side of the mountain. Here is a special case where the transmission of power, even with a very large investment, would result in a great saving. The conditions of mining in the West present a great many similar cases. The mines are oftentimes on the brows of hills, with water-power only a few miles away, but utterly inaccessible because of the difference of levels. I think that this field of work is going to present some of the largest opportunities for the transmission of power. Leaving these special cases of transmission for consideration at another time, the question is whether you are going into the transmission of power in a half-hearted manner, making it simply an adjunct to some existing circuit which you have, or whether you are going to take up with the energy which characterises the treatment of the arc and incandescent light problems, and, recognising the breadth of the field in which you have to work, enter into it in the spirit which guarantees success. To do otherwise is to invite failure. You must deal with the transmission of power the same as with any other business which is successful, exercising the same energy, watchfulness and enterprising spirit. As I have told you the practicability of the transmission of power is proven beyond all possible question. I am running now, I suppose, motors in twenty different cities in this country. I have never seen over one-tenth of them in operation. These motors are used not only in the United States, but we have introduced them into the Argentine Republic, Germany, Italy and Canada, and are about to introduce them into China and Japan. So you see it has gone far beyond the experimental stage.

Mr. WEISSLEDER: How about running a street railway where the conductors are six, eight or ten miles long?

Mr. SPRAGUE: We have to work at a potential of four, five or sometimes six hundred volts to get the highest economy in the transmission.

Dr. MOSES: In running your motors at this very high electromotive force, do you feel perfectly confident as to the vitality of the machines?

Mr. SPRAGUE: There is a limit to the electromotive force which you can use. In going to 7,000 volts I think M. Deprez has exceeded the commercial limit. All things being considered, I think 3,000 volts sufficiently high.

Mr. RIDLON: Would it be any better to use an alternating current than a constant current; the regular arc current of to-day?

Mr. SPRAGUE: While I believe it is possible to run motors on alternating currents, I have not gone far enough into that to state what the results have been.

Mr. RIDLON: Would it be of any assistance in running motors on an arc light circuit to use a distributing box, or to use it on an alternating current?

Mr. SPRAGUE: No, sir. I do not deny the possibility of running motors on arc light circuits. We are running on that class of circuit, but it is a limited field.

A number of questions were put to Mr. Sprague, which were finally summarised by Mr. Morrison as follows: It is not the intention of any of those present to discuss the motor business as a business exclusively. The question is whether they can take any part of the motor business at a profit, their business being arc lighting. Now, having a surplus of power, can that power be utilised at a profit to arc light companies? They do not propose to buy any more machinery; they do not propose to build additional lines, but to utilise the dynamos they have and to utilise the power they have.

Mr. SPRAGUE: Unquestionably they could do that, but that limits their capacity, and it makes the motor business simply an adjunct to electric lighting. Now, that is the great fault with many Edison stations I have had to deal with, making the motor business an adjunct to the electric lighting business. If one station I have in mind had taken the capacity of their station a few weeks ago, and run it for motors, they would get double the amount they are getting for light to-day.

Mr. POWERS, of Troy, N. Y., stated that he had started an arc light circuit for the purpose of supplying motors. A very large proportion of the power they would have to supply would be from 5 horse down. The difficulty they have met is how to reconcile the first cost of small motors used in parallel distribution on a 600 volt constant potential circuit.

Mr. SPRAGUE stated that with the distances in Troy 600 volts was unnecessarily high. Under suitable electromotive force the constant potential circuit would be found to be the cheaper. He said that he was considering the question of large powers and large areas, and that he was not content to deal exclusively with small powers. The tendency is to increase the powers of motors used. In Boston the motors used were first of ¼ horse-power; now they are run from ¼ to 15, and very soon will be higher.

Mr. LAW: This motor question resolves itself into this: A majority of those here are placed in this position. We have a certain number of arc circuits up; these circuits are not full of lights. We are not allowed by the laws of the city to place any more wires on the street. Now, the question is, Is it going to pay us to put in motors or not?

Mr. SPRAGUE: Unquestionably, yes; put all the motors you can on your circuits; the best motors you can get.

A MEMBER: How are we going to get at a method for charging them?

Mr. SPRAGUE: That depends a good deal upon the local management. My principle is to get all you can for them.

A MEMBER: You say you are running them on incandescent circuits in New York? What effect have they on the lights, and have you any system of regulation for maintaining constant speed?

Mr. SPRAGUE: As we are building our standard machines, they will run at the same speed, that is, within 1 per cent., under all loads up to the maximum. The machines are absolutely automatic. The large machines are of 91 per cent. efficiency. Not only that, but we have machines which run on a potential varying from 180 to 220 volts; that is, on a variable constant potential circuit, if I may use the expression. In Boston, we had one machine built for 110 volts running at 190 volts; in another case a machine for 110 volts was run on a circuit that dropped to 60 volts. This regulation depends upon the winding entirely. A machine wound on similar principles will run at a constant speed on a constant current circuit, but only when working below 50 per cent. efficiency. If working above 50 per cent. efficiency, an automatic mechanical governor is required. No matter what certain English scientific writers may say, it is impossible to wind a machine to run at a constant speed under variable load on a constant current circuit and work above 50 per cent. efficiency.

Mr. DUNCAN: We have a 60-light machine of about 2,500 volts. I am informed that we could deliver from that machine about 45 or 50 horse-power; take that as a figure. Can we run such a motor?

Mr. SPRAGUE: You can contract to deliver that number of horse-power, if there are a large number of small motors, on account of the intermittent use.

Mr. DUNCAN: We have a 2,500 volt arc light machine. Now, can we run a 45 horse-power motor, that is, one machine?

Mr. SPRAGUE: No, it would be utterly impossible.

Mr. DECAMP: Now, wouldn't it be better for us to put in a machine such as you recommend and double our wire and run the same amount of power? I am assuming that we have one machine on a circuit. We have another wire on the circuit. We couple these two wires together, making double, and reducing the potential at the machine. Can it be done economically?

Mr. SPRAGUE: If you will give me the exact condition of the circuit I will tell you.

Mr. DECAMP: Suppose each circuit is five miles long.

Mr. SPRAGUE: How much power are you willing to put behind the machine?

Mr. DECAMP: The same power as we use to run the machine for arc lights.

Mr. SPRAGUE: It will be necessary to have the full detail of your proposition before I can give you a definite answer.

Mr. WHEELER: Why is it not as well to run out independent circuits for large powers and work on constant current circuits.

Mr. SPRAGUE: With equal total electromotive force, the weight of wire would be the same, but with the constant current you would have a large number of circuits, the regulation would be far more difficult, and the advantage of intermittent use would be lost. There are many other objections, but these ought to be enough.

After some further discussion as to the practicability of supplying power from a constant current station,

Mr. MORRISON said: Mr, Sprague takes the ground that a successful motor service should be run from a central motor station. All of Mr. Sprague's argument is that the motor business pays better than the electric light business, and I think that he has proven that very satisfactorily by the figures he has given you. But it does not entirely solve the question which is being discussed here, how arc light companies can utilise their surplus current. He told you that if he had a company that had spare power he would use it. There is another thing here, he does not care to deal with small motors. He prefers the larger sized motors, and I think he is very sensible. If you come to 1 horse-power motors and ¼ horse-power motors, they can be put upon the arc light circuit; if you are going to abandon the electric lighting business and go into the motor business, then take the plan that Mr. Sprague suggests.

Prof. HOUSTON, having been introduced by the chairman, spoke as follows on "The future of electric motors":—

I have not very much to say on the subject of motors, but it seems to me of all the bright future which seems to be in store for us as those interested in electrical matters, that in the direction of electric motors the sky appears to be the brightest. For, when we bear in mind the economy which is possible in the electric motor (and I was glad to hear Mr. Sprague speak in such unqualified terms respecting it); when we consider the very great economy of the electric motor, its small bulk and the wonderful power it is capable of rendering, it seems to me that comparatively little is needed in order to permit the steam engine to become a thing of the past, and the dynamo-electric machine become the motor of the future. Of course, as we all know, such a state of things would be impossible as long as we have to rely upon the steam engine as a prime motor to furnish the electric current; but I take it that inventive genius will not be found long wanting to devise a practical means whereby the burning of coal can be directly applied to the production of electricity; and as soon as that is accomplished, then beyond any question the steam engine becomes a thing of the past—a toy—an historical piece of

apparatus. And ye, fellow workers, know what that means; ye engine and boiler men know what that means—when you can pack on a small floor space a machine capable of developing three, four, five, six, seven thousand horse-power if you only have the wherewith to put into it. I think the chances are that that will be solved. I think the chances are good, and that it will be made when one succeeds in solving the problem of how to change a current of low electromotive force into one of high electromotive force.

It is recognised to-day that coal can be burned to produce electrical power, and I do not think it requires any great prophetic power, looking into the future, to see that this is not only a possibility but a probability—and of the near future. I confidently expect to live to see it.

When it was proposed to cross the Atlantic by means of steam, it was shown beyond peradventure by the very best mathematical ability, by the highest engineer authorities in the world, that it would clearly be impossible for a vessel ever to cross the Atlantic Ocean by means of steam, because, as it was argued and proved, the coal necessary to supply such a vessel would sink the ship.

Now, gentlemen, on exactly the same plan, is it not true—will you excuse me if I vaporise a little—that the only thing that stands in the way of aerial navigation to-day is compact motor power? We can certainly fly, and we can certainly navigate the air, not by means of balloons, but by some motive power, if we can get a compact motor. It seems to me not only possible, but very probable, that the electric motor may solve this particular requirement. It may not be impossible that we shall live to see flying. I certainly expect not to fly myself, as that would require considerable power, but to see machines carrying their passengers through the air.

It does seem to me that of the attractions of this field, the most practical and the one in which the future is brightest to us, is in the direction of electric motors; and I believe, too, in electric motors on arc light circuits, even electric motors in series as well as electric motors on constant potential circuits.

THE NEW MANCHESTER TELEGRAPH OFFICE.

THE engineering staff of the Northern District, under Mr. J. Doherty, moved from their old quarters in York Street to the New Post Office last week. The new quarters are situated in the basement and are very compact and commodious. The whole of the offices are together, forming with the workshops, battery and engine room a large portion of the basement of the New Post Office.

The office in York Street ceased to be the telegraphic headquarters in Manchester at midnight on Saturday last (the 5th March). It may be recollected that the office at York Street was formerly the headquarters of the Electric and International Telegraph Company, and on the transfer became the Postal Telegraph headquarters in Manchester. Since that time (1870) several increases have been made in the house accommodation. On Saturday last the whole of the instruments were removed from the old building to the New Post Office in Spring Gardens and Brown Street. A work extending over many months has been entailed by the necessary arrangements for the transfer of so gigantic a department. The arrangements were all carefully planned in minutest detail, and they have been carried out perfectly and without hitch. The department is now in occupation of a finer suite of rooms than are used by the telegraphists at any post office in the provinces, and in some respects the new premises are superior to those devoted to telegraphy at the General Post Office, London. The instruments (some of which were new and necessarily fixed beforehand), numbering considerably more than 200, are fixed in three lofty, well-lighted, and well-ventilated galleries at the top of the Market Street end of the Post Office. There are close upon 500 operators for whom accommodation is provided. A portion of the building upon the same floor is fitted up for dining rooms for male and female clerks and as a kitchen for cooking purposes. The plan adopted in fixing the instruments has been to keep the busier circuits communicating with the larger towns in one gallery by themselves. There has been an extension of the pneumatic tube system in the town, and intercommunication between the galleries has been established. The engines for working the "pressure" and "vacuum" containers were formerly in use at Liverpool; the boilers, however, are new. A third engine (removed from York Street) will shortly be placed. In a succeeding number we shall refer to the telegraphic and other engineering details, including some account of the wires, test boxes, batteries, &c. It may be remarked, however, that with the exception of *four* wires only, all the vast network of wires entering the Post Office do so by means of pipes underground. Four wires only are of the overhead description. The whole of the arrangements were successfully carried out under the superintendence of the Divisional Engineer, Mr. J. Doherty, and of Mr. Mason who is in telegraphic charge of the new office as he was of the old. Mr. E. Graves, the Engineer-in-Chief of the Postal Telegraphs, came down from London to be present at this change, which in importance was second only to that of the transfer of the telegraph system in London from Telegraph Street to the General Post Office.

ROYAL JUBILEE EXHIBITION, MANCHESTER.

STEADY progress is being made with this exhibition towards completion, and as regards the building itself and its numerous adjuncts, there is every prospect of all being in working order, including the electric lighting, by the time required.

Some slight progress has been made with wiring for the arc lights, but the "fairy" fountain has not yet been completed, so that the arrangements for the fancy lighting have not yet commenced. The fountain is in the centre of the Botanical Gardens, and is formed in a large circular basin, specially constructed for the purpose. It is 153 feet in diameter, and pumping machinery is provided capable of raising upwards of 200,000 gallons of water per hour. A small pavilion has been erected amongst the trees on one side of the gardens for the person who will have charge of the fountains. It will be fitted with an elaborate key-board and electric light switches, and a variety of beautiful effects will be produced, not only during the day, but during the evening. Owing to the improvements and additions effected by the late Sir Francis Bolton, and by Mr. Galloway, it is anticipated that this fountain will excel in beauty and novelty the celebrated one at South Kensington.

The greatest progress in the electric lighting department has been made under the contract with the Manchester and District Edison Electric Light Company, for the incandescent lighting. The whole of the Fine Art Galleries, which will be illuminated by 1,650 Edison-Swan 16 C.P. lamps, has been wired with the necessary leads, branches, and mains. The last are of some importance, as the dynamo room is over 300 yards distant. This section is ready for fixing the lamps. Great progress has also been made with the leads for the "Old Manchester and Salford" section, and the subsidiary mains have been laid. The mains themselves will be laid in the course of a few days. These are, as may be imagined, of still greater importance, as the dynamo room is distant a quarter of a mile away from the lighting of this section.

From the incandescent lighting point of view it must be considered that the position of the dynamo room, so very far off, cannot tend towards economy in the working, in consequence of the heavy mains required, and it is contended that the lighting would have been better and cheaper had the power been nearer to its application. But as the whole of the boiler power has been placed at the service of the exhibition authorities gratuitously, it was necessary to have all the engines and dynamos immediately adjoining. Some progress has been made with the lighting arrangements in the palm house, to be used as the dining rooms. This section and that of "Old Manchester and Salford" will be run by the dynamos about to be removed from the Edison Company's central station in Manchester, which ceases to exist after to-morrow. The other dynamos for the incandescent lighting of the Fine Art Galleries are being supplied by Messrs. Mather and Platt, who are placing the necessary number at the disposition of the Exhibition Committee free of all cost.

A NEW TELEPHONE.

TELEGRAPHING on Tuesday last, the Paris correspondent of the *Times* said:—"I was invited to be present to-day at some telephone experiments between Paris and Brussels with a new apparatus known as the 'micro-telephone push-button.' These experiments, which were made on behalf of the two telegraphic administrative departments of France and Belgium, produced a very lively impression on those present, and I believe the new apparatus to be the most perfect yet produced.

"As its name indicates, it has the form of an ordinary electric push-button. When the button has been pushed in, and has made a sound at the other extremity, it is taken out, and is found to be attached to a long electric wire. There is thus exposed the telephonic plate, which is extremely sensitive, so that where it is necessary to speak at short distances it is not necessary to come close to the instrument. For communications in the same street, or the same house, the operator places the upper part near himself, and without changing his position he can speak with the correspondent at the opposite extremity. He is not obliged to put his ear to the part which contains the button and brings back the reply. Thus for short distances those who make use of this apparatus speak in their ordinary tone, without changing their customary attitudes. They may sit or walk about, and speak just as if those they are addressing were present. When great distances intervene, as in the experiments performed to-day, in which the speakers and hearers were separated by 200 miles, it is necessary to come nearer to the apparatus, but without being obliged to speak quite close to it.

"But what makes this apparatus the most successful of telephonic instruments is, that it can be made for half-a-crown, that is to say, for not more than the price of the ordinary push-button. Now, as it can be fitted to the electric wire of the ordinary ringing apparatus, it follows that it introduces a complete change in our ordinary modes of intercourse. At front doors, in the interior rooms of houses, everywhere, in short, where the ordinary electric buttons are used, the telephonic button may be introduced. It will by this means be possible to give or receive instructions, to know who is knocking at the door, to communicate in short, by speaking as well as by ringing. On the advantage of this in everyday life it is unnecessary to dwell. The railway companies

are making experiments with this apparatus as a means of communication between compartments of carriages. It is being fitted up on trial in hotels. I have seen it at work at the door of a private house, where I was replied to by those within without their having stirred from their places, and without the door being opened. Between Paris and Brussels this instrument, costing half-a-crown, worked with admirable precision, and it was not altogether without an eerie feeling that I listened to a voice with a slight Belgian accent coming to me from a distance of more than 200 miles.

"The inventor is Dr. Cornelius Herz, one day nominated Grand Officer of the Legion of Honour, next day described as an emissary of Germany, and lastly as the friend, adviser, and confidant of General Boulanger. He is in reality an electrician whose inventive talent has been stimulated by his residence in America, where there is a boundless demand for improvements in electrical apparatus and in all mechanical contrivances. The French Minister of Posts and Telegraphs, under whose auspices the experiments were carried out to-day, has approved the report made to him, and proposes to give orders for the introduction of the new apparatus into all the public administrative departments as soon as it comes into use, for as yet it has only been an experiment."

NOTES.

Electric Lighting of Public Buildings in Birmingham.—At a meeting of the Birmingham Town Council last week, the Mayor read a letter from Mr. Arthur Chamberlain on behalf of the Midland Electric Light and Power Company asking the committee to consider a proposal for the extension of the electric lighting of the round room at the Art Gallery to other rooms in the building. The company would be willing to provide, fix, and run at its own cost the requisite engines, dynamos, and other plant, and take all the responsibility connected with them, supplying the Art Gallery at a fixed charge per lamp per annum if, in addition to the Art Gallery, the Town Council would grant them the right to light the Town Hall. With these two arranged for, the company could obtain a portion of the lighting of other public buildings in the immediate vicinity, and thus spread their establishment charges over something like 1,200 lights. The company would supply the light in the Art Gallery for £1 per lamp per annum for as many hours as the committee liked from dusk to 9 p.m., and for as many evenings a week as they wished. If they used them six nights a week, as they probably would do as soon as they had the electric light, it would be as cheap as, or cheaper than, gas for the same amount of light. All the present leads, lamps, and reflectors in the round room would be utilised, while the sale of the engine and dynamo would realise enough to pay for the wiring of the other rooms. The advantage of this arrangement to the Art Gallery, avoiding as it did all capital outlay, attendance, and risk, would be seen, and the company was prepared to offer equal advantages to the users of the light in the Town Hall. At present the latter had to pay £10 a night for the electric light, including the use of lamps and electroliers, but not including the charge for gas in various parts of the hall. There were in consequence of this high charge many complaints and few users. The company was prepared to supply it in the same way for a charge of only £5 per night. The Mayor moved that the communication be referred to the General Purposes Committee. The motion having been seconded, Mr. Brinsley said the letter looked like an advertisement of something which was in competition with the Gas Committee, and the less encouragement they gave to it the better for the borough. The motion was carried.

Electricity for Fortified Towns.—The War Department at Madrid is moving in the matter of providing electric search lights for war purposes, according to *Industries*, and a trial order for a large dynamo has been given to Oertling of Switzerland. It is intended to provide search lights for all the fortified towns, and probably some also for encampments. A number of accumulators are being made at Madrid, on the model of a well-known officer in the artillery corps.

Electric Light at Taunton.—The county town of Somerset has, thanks to the pressure brought to bear on the authorities by the inhabitants generally, the proud distinction of being the only place in England which is at present publicly illuminated by means of electricity. Mr. H. G. Massingham, of Bath, whose contract was accepted, has provided a capital installation, and his depôt has been visited by many experts from various parts of the country who have been directed to report on the system. Mr. Massingham understands that the result of these reports is so satisfactory that several towns will this year signalise the Queen's Jubilee by the introduction of the electric light.

Midland Electric Lighting Work.—Electric light engineers are finding an increased call for dynamos and accumulators of accredited design, the *Engineer* states in its Wolverhampton and district article. Not only are home orders growing for lighting and power purposes, but an extended trade is being done abroad—Australia, India, Spain, Holland, and Germany are all buying. The Elwell-Parker Company, Wolverhampton, is very busy, and is employing some 250 hands. Among the export work which it has recently executed were accumulators and dynamos of 70 horse-power to supply 400 or 500 incandescent lamps for the lighting of a Spanish cotton mill; and a dynamo of 25 horse-power for 100 incandescent lamps for the lighting up of a native Indian palace. The country work now in hand at these works includes accumulators and dynamos for Woolwich Arsenal. Other valuable home and foreign work is early expected.

The Electric Light in the House of Commons.—The electric light which has been used in the Commons Library, under the galleries, in the ante-rooms to the Reporters' Gallery, and in other parts of the building with conspicuous success, was found to be unavailable during a part of the evening last Friday, not, we are informed, in consequence of any failure in the light or in the machinery producing it, but by reason of a defect in the pipe which feeds the boiler from which the electric lighting machinery is driven. The library and ante-rooms were lit for the evening mainly by oil lamps. It is not a little strange that those who have the lighting of the House in charge have not yet discovered the virtues of secondary batteries, the use of which would have prevented the failure of the light.

Electric Lighting of the Prudential Company's Offices.—At the meeting of the shareholders of the Prudential Assurance Company last week, the deputy-chairman said there was an interesting matter connected with the office during the past year. They had abolished gas throughout the whole of their large offices, and had adopted electric light, which, although it might be a little more costly, was a great help to their employés. This light had been employed during the late period of valuation, when their clerks were engaged from eight in the morning till eight at night. There were 1,200 lights in use at present, but when the new building was completed there would be 1,500 lights going, and it was due to those who had established the system to let the shareholders know that it had worked thoroughly satisfactorily.

Electric Lighting of Steamers.—The trial trip of the *Duitschland* took place on Wednesday week. The *Duitschland* is one of the three sister vessels which have been built by the Fairfield Shipbuilding and Engineering Company, Limited, to the order of the Zeeland Steamship Company, and which are to run between the ports of Queensborough and Flushing in connection with the London, Chatham and Dover Railway and the Netherland State Railway. The other vessels are the *Engeland*, which will be completed within the next few weeks, and the *Nederland*, which was launched on the previous day. The steamer has been fitted throughout with the electric light by Mr. J. F. D. Andrews, of the Woodside Electric Works, Glasgow, and also with electric bells.

The Electric Light in the Suez Canal.—An Exchange Company's telegram of March 1st states that under the new regulations, the Peninsular mail steamer *Siam*, Captain Dorchester, from Bombay, passed the entire length of the Suez Canal with the electric light in 15 hours from Suez to Port Said without a hitch. This is, it is said, the first instance of the navigation of the whole length of the canal by electric light, and the captain of the ship and the canal authorities were highly pleased with the result.

Yacht Lighting by Electricity.—Messrs. Muir and Houston, of Glasgow, have been instructed to build a large screw yacht for Mr. John Donaldson, of Chiswick. The yacht is to be fitted throughout with the electric light.

Electric Lighting of Ships.—At a meeting of the Executive Committee of the *Mars* training ship at Dundee, it was resolved to introduce the electric light on board the ship. The committee has accepted the offer of Messrs. Thompson & Ritchie, London, to carry out the work.

Electric Lighting for the Paris 1889 Exhibition.—M. Fontaine has taken the initiative, says *Industries*, in the formation of a syndicate, comprising the principal electric lighting firms, which has for its object the organisation of the electric lighting of the forthcoming international exhibition. The leading idea in the action taken by M. Fontaine is, that the lighting should not be farmed out to one or two great companies, but that all the different systems should, as far as possible, be exhibited, and should share in the work to be carried out.

Lighting of Trains.—With reference to the paper by Mr. H. Corderoy, which we published last week, that gentleman writes to us to say that he inadvertently stated that Pintsch's gas was introduced in 1880, whereas it should have been 1875; also that Pope's system has only been used experimentally for a short time on the Metropolitan Railway.

Electric Lighting of Theatres.—To-morrow evening (Saturday) will be the last performance by aid of the electric light at the Theatre Royal, Manchester, at least for some considerable time. This theatre has been electrically lighted by the Manchester and District Edison Electric Light Company from the central station in Mount Street, near the Theatre Royal, from December, 1882, so that the lighting has continued from the same place for upwards of four years. During the present pantomime season the performances have been twice daily for five weeks, and for the rest of the run about nine performances per week, so that almost constant attendance has been required at the lighting station. The lighting of this theatre has been most successful and continuous, never once being interrupted, and the utmost satisfaction has been expressed by the public. The "Comedy" Theatre and other places have been lighted also from the same station. The various dynamos at present in use at this station will be at once removed to the Jubilee Exhibition, where they will be required for the lighting of the large dining-room and for "Old Manchester and Salford." As the same dynamos have been running at this installation from the very commencement, they present some features of interest as to the durability of the "Edison" class dynamo, and we hope in some future number to give some authentic particulars as to the working of this installation.

Electric Light at a Concert.—The Lewisham Bicycle Club has again adopted the electric light at its smoking concerts, one of which was held at the club on Saturday. The whole of the building was illuminated with incandescent lamps, while outside a large arc light was suspended. The current, as before, was taken from accumulators supplied from the works of Messrs. Arthur B. Gill & Co., electrical engineers.

The Electric Light on the Bar Lightship.—Owing to remonstrances from steamboat owners, that the lightship could not be well distinguished from the brilliant masthead light which many steamers showed, the Mersey Docks and Harbour Board had a number of experiments made, and, *Industries* states, have come to the conclusion that the electric light is unsatisfactory, and having consulted the Trinity House, they intend to adopt their recommendation to substitute powerful oil lamps in its stead. The experiments with the electric light have cost about £2,500.

Electric Lighting in the City.—"Dogberry," writing in last Wednesday's *City Press*, states that for some time no steps have been taken with regard to the use of the electric light in the City, the contract for lighting a part of the City which was entered into between the Commissioners of Sewers and the Anglo-American Brush Electric Light Corporation having been suspended about a year ago. "The experiments, though of a temporary character, met with general satisfaction," he says, "and although there may be difficulties to overcome, I hope the Commission will not lose sight of the importance of securing the permanent illumination of the City by means of the electric light at the earliest opportunity."

A Government Telephone Exchange at Melbourne.—The Victorian Government has for some time been endeavouring to secure the exchange of the Telephone Company at Melbourne, but the latter has been so extravagant in its demands that the negotiations have come to nothing. The Government, however, has resolved to open an exchange for itself. The other day a deputation from the Melbourne Chamber of Commerce waited on the Postmaster-General to urge the Government to take immediate action to establish a telephone exchange, with the latest modern appliances. Mr. Derham stated that he was doing all he possibly could in the direction indicated by the deputation. He had received news by cable from the Agent-General that information of the greatest value with reference to the establishment of a telephone exchange had been forwarded by post. He assured the deputation that the Government was in earnest in its desire to establish a telephone exchange.

The Telephone at Bath.—Unfortunately, from various causes, the telephone exchange which was established in Bath some time since has met with scant support at the hands of the inhabitants, and at the last meeting of the Council the Town Clerk read the letter from the Western Counties and South Wales Telephone Company which ought to have been produced on a previous occasion. In the course of this communication, the general manager and secretary (Mr. Lewis) expressed disappointment at the slow growth, or he might say the complete standstill, of the telephone system inaugurated by the ex-Mayor. Considerable capital having been expended, it would be a matter for deep regret were it to happen that, owing to the apathy of the citizens, the company should be forced to abandon its efforts. In this want of appreciation, Bath stood alone among the towns in which the telephone had been established, and if their expectations were not realised in a very short time the directors would have no alternative but to close the exchange, which they would not reopen until they had at least 50 signed orders to begin with. Mr. Collins said that the company had never received any encouragement to extend its operations to Bath, and could not therefore complain at having been unsuccessful. The ex-Mayor having observed that the Corporation could not create subscribers, the matter dropped, the letter being allowed to lie on the table.

Destruction of Telegraph Plant.—Several young lads from 14 to 18 years of age were last week brought before Sheriff Bell at Falkirk, charged with maliciously breaking telegraph wires between Carron and Camelon. They were fined from 5s. to 7s. 6d. each.

Telegraph Extension.—In the House of Commons on Friday last, in answer to Lord E. Hamilton, Mr. Raikes said that the question of extending the telegraph to Burton Port and Dungloe had been under the consideration of the Government, but it had been decided not to make the extension at present.

Telegraphic Communication in Ireland.—Mr. Raikes stated in the House of Commons last week that he was unable to grant a request which had been made that direct telegraphic communication should be provided between Wexford and Enniscarthy, because the amount of business between the two towns would not warrant the expense. He was, however, prepared to expedite the transmission of telegrams by improving the existing means of communication. The daily number of messages was about eight, and the average time of transmission 15 minutes.

Telegram Cards.—Replying, on Monday, to the query of Mr. Puleston with respect to telegram cards, the Postmaster-General said such cards were first issued to the public in January, 1872. There was, however, no demand for them, and the Department came to the conclusion that they were not required. They were withdrawn after four year's trial.

Overhead Wires in Dover. — The Dover Town Council discussed the subject of the telegraph and telephone wires at a recent meeting. Some councillors were in favour of a request being sent to the railway companies, who own the telegraph lines to which objections were raised, to place those wires at a greater height, so as to allow of the free passage of the fire escape; others, and these predominated, thought a test should be made as to the facility with which the fire-escape could be lowered before a demand involving such a large expense was made upon the railway companies. The telephone company has promised to increase the height of its wires.

Quite Harmless.—Cheeky Passenger: "Any fear o' my disturbing the magnetic current, captain, by going near the compass?" Captain: "Oh, no, sir. Brass has no effect on it whatever, sir."

Electric Locomotion in New York.—M. Julien could scarcely have chosen a better time for exhibiting his motor in New York City, says the *Scientific American*, for quite recently the largest, richest, and most enterprising of the surface roads, to wit, the Third Avenue, decided to adopt cable traction, or electrical, or any other which promises to relieve them of their costly and troublesome horse service. If, therefore, he can show that the electro-motor may be made to give as reliable and as economical service as the cable, he will find a ready market, and one capable of being developed almost indefinitely.

Society of Arts.—Mr. Reckenzaun's paper on "Electric Locomotion" is to be read before the Society of Arts, on March 30th. For the papers of Prof. Silvanus Thompson, on the "Development of the Mercurial Air Pump," and Mr. W. H. Preece, on "Progress in Telegraphy," no dates have yet been fixed.

Accumulators in Austria.—The works for the manufacture of the Schenck-Farbaky accumulator at Baumgarten, near Penzing, says the Vienna correspondent of *Industries*, are assuming considerable proportions, and provision is being made for the production of secondary cells on a large scale. The positive plates contain a mixture of minium litharge and carbon powder, whilst the negative plates contain litharge and powdered pumice stone. The efficiency in ampère hours is stated by the makers to lie between 85 and 90 per cent.; that in watt hours is stated to lie between 70 and 75 per cent. The construction of the cells is very durable; but as they have not yet received an extensive application, there is no experience as to their life. The prices also have not yet been fixed.

Portable Electric Search Lights.—Writing to *Industries* from Paris, M. Henri Serrin says:—"Will you permit me to point out that the first automatic focussing lamp working in all positions was shown in 1881 by my uncle, M. Victor Serrin, at the International Electrical Exhibition in Paris? This lamp was specially constructed for naval purposes. A simple parabolic reflector was used, thus rendering the whole apparatus light, and enabling it to be transported to any point of the ship, and to be easily handled by one man. In consequence of the experience gained by M. Serrin with the electric light during the Franco-German war, he thinks that a parabolic reflector gives as good results as the projector."

Electricity at Panama.—M. Desson, of Brussels, has, *Industries* states, received an order to supply, for the Panama Canal, several electrical appliances for exploding dynamite cartridges under water. The apparatus includes a dynamo capable of exploding up to 500 cartridges simultaneously, and a switch-board. The dynamo will also be employed for lighting purposes.

Electric Tramways in Brussels.—The Brussels correspondent of *Industries* announces that a new electrical tramway is under consideration, which is claimed to be more simple than that which has been tried in Brussels for some months, and the management of the accumulators is more rapid and easy. The mechanical portion also shows considerable improvement.

Proposed Electric Launch Competition.—Something exciting in the shape of a race between electric launches is promised. Messrs. Lester and Perkins, of the Royal Albert Dock, are building a launch under special arrangement with the Electric Locomotive and Power Company, and Messrs. Stephens, Smith & Co., the builders of the electric launches constructed in accordance with Mr. Reckenzaun's patents, have offered to place the *Volta*, which, it is stated, will be entirely remodelled before being again put into the water, into competition with the new launch in a race across the Channel, on condition that the latter boat is built and equipped by Messrs. Lester and Perkins themselves and at their own cost. The owners of the launch which takes the longest time to cross from Dover to Calais, it is suggested, shall pay £25 to the Poplar Hospital and £25 to the West Ham poor box. We are informed that there is every probability that Messrs. Lester and Perkins will accept the challenge, and that Messrs. Stephens, Smith & Co's. conditions will be agreed to. The newer launch is built by the firm of Lester and Perkins at their own yard and at their own cost. Mr. Elieson has arranged to supply the machinery at his own cost, this arrangement being entirely independent of the Electric Locomotive and Power Company, which has the option of taking the boat over at cost price when it is demonstrated a success.

Bleaching by Electricity.—A paper on Mr. Hermité's process of electrical bleaching was read before the Society of Chemical Industries on Monday evening by Mr. Charles Cross, member. The process, as we have previously described it, consists in electrolysing in specially constructed tanks a solution of chloride of magnesium, which is afterwards employed for the bleaching of the fibres, yarns, &c. According to Mr. Cross, who has made exhaustive experiments to determine the commercial value of the process, the saving is considerable as compared with the cost of ordinary bleaching by chloride of lime. Some theoretical points raised by the author of the paper will be discussed at a future meeting of the society.

Dynamos Extraordinary.—In the number just issued of the *Journal of the Society of Telegraph Engineers*, Mr. Jas. Swinburne is reported to have said in connection with the discussion on Mr. Kapp's paper, that the induction in the armatures of the Bürgin machines at the Colonial Exhibition reached $2{\cdot}48 \times 10^8$ Kapp lines per *acre*! Shades of Faraday! Does Mr. Swinburne now design machines whose magnetic "fields" are measured by the acre?

Electric Tramways.—Are we correct in assuming that the three miles of tramline, for the construction of which Mr. Holroyd Smith is asking tenders, is to be laid out in Algeria?

A New Journal.—The Italian Chamber of Commerce in London will publish three times per month a new periodical called *Giornale della Camera di Commercio Italiana in Londra.*

Scientific News.—This is the title of a fresh venture for supplying general readers with technical information. *Scientific News* is published monthly, and the first number contains 24 pages of varied and interesting matter.

Overhead Telegraph Wires.—We are informed that the City Commissioners of Sewers have decided in future not to entertain applications for permission to lay pipes for telegraph wires in the streets under their control.

Catalogues.—We have received a copy of the second edition of the Electric Light List of the Electric Apparatus Company. It appears to give particulars and prices for everything that can possibly be required in connection with installation work. Messrs. Ransomes, Sims, and Jefferies have sent us an illustrated list of their winding and hoisting machinery, in which is given a description of different types of engines, including their new long stroke expansion stationary engine, the special arrangement of which is said to effect two results much appreciated by electrical engineers, namely, economy in fuel and regularity in speed.

Paris International Railway Exhibition.—A special marine section is being constituted in connection with this exhibition, which opens in May next. The exhibits will be divided into nine groups, including raw material, life and other boats, marine engines and boilers, naval ordnance, lighthouses, fog and other signals, and all kinds of appliances. Group VI. embraces "Submarine telegraphy, torpedo nets, torpedoes and diving dresses and gear, with electric apparatus for use with same." The registered office is at New Broad Street House, E.C.

Removal.—Nalder Bros. & Co., late of 8, Victoria Chambers, Westminster, and Brentford, have removed their works and offices to Westminster Engineering Works, 132, Horseferry Road, Westminster. The firm now consists of Mr. F. H. Nalder, Mr. H. Nalder, and Mr. C. W. S. Crawley.

Art Fittings for Incandescent Lighting.—Messrs. Laing, Wharton, and Down have just issued a new list with prices and sketches of their electroliers, brackets, pendants, lamps, shades, switches, and batteries, including some specialities in the way of hand-wrought copper fittings for house lighting. The copper being relieved with brass and trebly lacquered, a brilliant appearance is secured without involving any trouble in keeping the metal bright. The fittings impart a pleasing glow to the light, are designed to harmonise with almost any style of furniture, and are moderate in price.

Electricity in Mining.—The Transactions of the Mining Institute of Scotland, Vol. VIII., Part 8, contains a long paper by Mr. F. J. Rowan, C.E., on the applications of electricity to mining operations. The topics dealt with include those of lighting, haulage, pumping, winding and ventilation. The experiments of Marcel Deprez on the transmission of power are noticed, and the author compares the various systems of transmitting power. The paper appears to have been very ably prepared, and it is well worthy of perusal by those who are interested in mining operations. Several plates of illustrations accompany the text, amongst them being a good sectional view of the Immisch motor.

Our Columns.—We have been obliged, notwithstanding an increase in the number of our pages, to leave over several articles of importance. This has been rendered necessary mainly by the length of our book reviews, the paper on electric motors with the discussion thereon, and the reply of Prof. Silvanus P. Thompson to the criticisms passed upon his paper on "Telephonic Investigations."

The Lighting of St. Austell's.—We are informed that the electric lighting of St. Austell's, Cornwall, commenced on the first of the month. This installation has received notice at various times in the REVIEW, but we hope shortly to be in a position to give our readers full information respecting it.

The Upward Battery.—We hope to publish in our next issue a full description of the modified form of battery which Mr. Upward has just completed. Several improvements have been introduced since the battery was first described in the REVIEW.

The Wheatstone Bridge.—In *Annalen der Physic und Chemie*, No. 4, of this year, Prof. H. Weber has a mathematical paper on the theory of the Wheatstone Bridge.

Overhead Wires.—At a meeting of the United Wards Club in the city last Friday, the subject of overhead wires was discussed, and some of the remarks made will strike our readers as being not a little curious, illustrating the folly of attempting to deal with subjects on which no trustworthy knowledge is possessed. Mr. Belcher said no one had seconded the motion by Mr. Ware: "That in the opinion of this club all telephone and telegraph wires should be carried underground." He now had much pleasure in seconding the motion. Germany and America had their wire underground, and Mr. Donald Nicoll, a celebrated civil engineer, had shown that it could be done here. Anything that might happen to wires underground could be easily seen to, and the cost was less than the overhead system. Then, perhaps, the most important matter was that in case of a storm no harm would come to wires underground. Mr. Deputy Cox remarked that the greater body of local parties were thinking over the matter of these wires, and the Metropolitan Board of Works had been collecting information on the subject. He had had the pleasure of hearing professional evidence, and there could be no doubt that the facts laid before the meeting by Mr. Belcher were most important. There had been but two objections to these underground wires—those of insulation and cost. These matters having been overcome, there was nothing left in the shape of opposition. The only question now was, should the control of such matters be left with local bodies, instead of the time of the Metropolitan Board of Works being frittered away with that and other similar things? The control, he believed, should be placed in the hands of the various districts. He believed the Metropolitan Board of Works would shortly ask for power to deal with overhead wires. Mr. Fyfe said that the Post Office authorities had come to the conclusion to have underground wires, and, indeed were carrying out the work as quickly as possible. It was not a matter of talk, but was actually being carried into practice. It would be well to try and get the Post Office to take over the telephone business, as it had been stated that the telephone could be carried on with the telegraph wires. This would be a great reduction of expense. Mr. Ware having replied, the motion was carried *nem. con.* It was resolved that an invitation be sent to Mr. Donald Nicoll, asking him to attend and address a meeting of the club in April.

The Victoria Station Lighting.—A correspondent informs us that the Edison-Swan Company has replaced the incandescent lamps at Victoria Station by arc lights. Two-thirds of these are of the Brockie-Pell type, the remainder being Pilsen lamps.

Practical Information.—In many electric light stations wires are run on the brickwork or on a cement floor, says the *American Engineer*. Bricks and ordinary cement are exceedingly porous, and if water reach any part the whole becomes somewhat damp. Dynamos are placed directly over such a floor, and the intervening wooden base may become damp enough to make quite a dangerous ground at the machine, in case, as often happens, there is connection on some part of the filled magnets with the wire. It is stated that by thoroughly drying the brick and cement work, and saturating it with asphalte, applied boiling hot with a brush, it will be found that the dampness can be prevented and good insulation insured.

Pre-Transfer Telegraph Clerks.—In reply, last week, to Mr. H. Wright, who wished for information respecting the position of telegraphists who were in the employ of the companies, and who entered the service of the Postmaster-General at the time of the transfer of the telegraphs to the State, Mr. Raikes said a large number of these officers had obtained promotion, while the remainder, though on a scale of wages not exceeding 50s. a week, were much better off than they were under the companies.

A Hint to the British Association.—As a result of the attempts to bring to pass an earlier publication of the Proceedings of the American Association, says *Science*, the proceedings of the Buffalo meeting held last summer were published during January of this year. Heretofore the proceedings have not been published much within a year after the date of meeting. This promptness in publication has resulted partly from the reduced volume of the Proceedings, and partly by obliging the authors of papers to furnish abstracts prior to the time of reading them. Several of the addresses and reports were in type and stereotyped before the meeting, and others were held in type ready to be incorporated in the order of printing.

Electric Light Wires.—Mr. Weeks read a paper before the National Electric Light Association on the subject of "Popular Prejudice against Electric Light Wires," giving a forcible account of some of the absurd ideas prevalent regarding the nature of electric currents. During the discussion a pamphlet issued by the New England Insurance Exchange was read, in which it was stated that electric lighting plants are considered by the insurance companies the safest of all means of illumination.

Personal.—In the *World* of last week we read, "Mr. Pender with a party of friends, among them Lord Bury and Mr. Keeley Halswelle, is going for a cruise in his splendid yacht *Electra*. Barcelona, Athens, Tunis and Malta will be among the places visited." We suppose this to mean that the cable steamer *Electra*, and not the *Volta* as was expected, is starting on a cruise for the inspection of the Eastern Telegraph Company's Mediterranean stations, although we fail to understand, in this case, the visit to Barcelona and Tunis. In any event the trip will not be uninteresting to the visitors on board, who will probably be duly initiated into the mysteries of submarine telegraphy, and perhaps will develop a gratitude which may in time bear fruit to their hosts, the Eastern Company.

Signalling in the Royal Navy.—Staff Commander J. R. Osborne, of the *Royal Adelaide*, has designed a new naval semaphore, which can be used with gas on shore and with the electric light at sea, requiring in the latter case only eight incandescent lamps for its illumination.

Callender's Cables.—We are informed that the Callender Insulating Company of New York has just received an order from the Edison Company for $50,000 worth of cable.

High Insulation.—At the Philadelphia meeting of the National Electric Light Association, Mr. C. C. Haskins read a paper on "High Insulation," in which he showed that many electric light wires were the reverse of insulated when soaked with rain. He advocated higher insulation than usually prevails and a rigid test.

The United River Plate Telephone Company.—The reports we have received from Buenos Ayres of the proceedings of this company, says the *Financial Critic*, are anything but encouraging, and unless the policy is thoroughly altered without delay, it is likely to result in grievous loss to the shareholders. The United Company began its operations on January 1st, and seems to have successfully managed to create general dissatisfaction during the very short time of its existence. As long as the two rival companies were at work the service was good at moderate charges; since January 1st it has become unreliable (through communication being nearly everywhere stopped), and the charges are almost doubled. Naturally enough, the people of Buenos Ayres will not submit to such treatment, and consequently encourage the formation of new telephone companies, four of which are already spoken of, viz., an Argentine, a French, a United States and a co-operative one. Moreover, house owners not only refuse permission to Mr. Fels to place new lines over their buildings, but many persons have even gone so far as to withdraw their former consent, and are cutting down existing poles, unless removed at once by the company, which they appear to be fully entitled to do. The amalgamated concern, which opened business with 10,000 subscribers, is said to have lost already large numbers of these, and the look-out for the proprietors is therefore very bad. A French enterprise, a branch of La Société Générale des Téléphones de Paris, has taken advantage of the situation, and has already begun business.

The Sultan and the Cable.—According to a telegram from Madrid to the *Times*, a journal published at Ceuta states that the Sultan of Morocco, on learning that a cable had been laid from Europe to Tangier, gave orders that it should be cut at once.

The E.E.F.C.—The football club of the students at the College of Electrical Engineering, Hanover Square, held a successful smoking concert at the Mason's Hall Tavern, City, on Wednesday evening last, when it was demonstrated that not a few of their number possess considerable musical ability. Mr. Elworthy who was present as a visitor, rendered valuable assistance as accompanist to several of the songs.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Rose Primary Battery Company, Limited.—An agreement of 22nd ult. provides for the purchase by this company from George F. Rose, of Rosslyn Hill, Hampstead, of the letters patent, No. 7,028, dated March 25th, 1886, for improvements in electric batteries for lighting and motive power. The purchase consideration is 20,000 fully paid shares of £1 each.

Electric Locomotive and Power Company, Limited.—Four agreements dated 5th inst. respectively, have been filed with the documents of this company, authorising the issue of fully paid ordinary £5 shares upon the surrender of 6 per cent. debenture bonds of the company as follows:—To the Earl of Galloway, 100 shares; Mr. J. J. Griffiths, 100 shares; Mr. W. H. Protheroe, 100 shares; and Mr. C. P. Elieson, 200 shares.

Eastbourne Electric Light Company, Limited.—An agreement dated 19th ult. and filed on the 7th inst. between the Anglo-American Brush Electric Light

Corporation, Limited, and this company, cites that the Anglo-American Corporation are the holders of four debentures of £100 each in the Eastbourne Company, and with a view to assist the latter company in continuing operations, will surrender half the said debentures and accept in lieu thereof 20 ordinary £10 shares, fully paid.

Primary Battery Company, Limited.—At an extraordinary general meeting of this company held at Cannon Street Hotel on January 5th, the following special resolution was passed, and was confirmed at a meeting at the same place on the 1st ult. :—"Resolved that the directors be, and they are hereby empowered, to effect sales of all or any of the company's patents in the United Kingdom or abroad, on such terms and conditions as they may deem best in the interests of the shareholders, and any contracts for sale already entered into by the directors be now and they are hereby confirmed." The resolution was duly filed on the 3rd inst.

Laing Electric Light Company, Limited.—The annual return of this company made up to the 26th ult. was filed on the 3rd inst. The nominal capital is £1,000,000 in £10 shares. 12,007 shares have been taken up, and the full amount has been called thereon. £120,000 is considered as paid on 12,000 shares, and the calls unpaid amount to £70.

Atlas Electric Appliances Company, Limited.—The annual return of this company made up to the 26th ult. was filed on the 2nd inst. The nominal capital is £2,000 divided into 500 founders', and 1,500 preference shares of £1 each, 707 shares have been taken up, and the full amount has been called thereon. £450 is considered as paid on founders' shares, and £250 on the preference shares and £7 remains unpaid. Registered office, 206, St. George's Street, E.

NEW COMPANY REGISTERED.

Regenerative Electric Light Company, Limited.—Capital £50,000 in £1 shares. Objects: To purchase the sole right to use and dispose of in all parts of Great Britain and Ireland other than Scotland, electric pile or batteries constructed in accordance with the patented process of Felix de Lalande (No. 1,464, dated March 27th, 1882), and to acquire such of the property and assets of the Standard Electric Light and Power Company, Limited, as may be necessary for the business of the company. Also to acquire for the United Kingdom other than Scotland the patent rights for improvements in galvanic batteries and the utilisation of the products therefrom (No. 40, dated January 1st, 1884). Signatories (with 1 share each): C. A. Morgan, 17, Cornhill; G. S. Harrison, 26, Stonor Road, West Kensington; R. Toulson, West Croydon; H. A. Neeve, Catford; A. E. Downes, New Southgate; Hy. Bennett, South Norwood; J. Milligan, jun., Windsor. Registered 7th inst., without Articles of Association, by Morley & Sherreff, 53, Gresham House. Registered office: 7, Westminster Chambers, Victoria Street, S.W.

CITY NOTES, REPORTS, MEETINGS, &c.

The Maxim-Weston Electric Company, Limited.

THE sixth ordinary general meeting of this company was held at the Cannon Street Hotel on Friday last, when Mr. Hugh Watt, M.P., chairman of the company, presided.

Mr. John Wright, the secretary, having read the notice convening the meeting, and the report, which we published last week, having been taken as read,

The Chairman, in moving the adoption of the report and accounts, congratulated the shareholders upon the position of the company, and upon the fact that for the third time the directors considered themselves warranted in recommending the payment of a dividend, which he thought he might describe as substantially made out of the profits earned. He did not wish to repeat the old, hackneyed phrases with regard to the existing depression of trade. Of course, all traders were only too conversant with the fact, and that a new industry like electric lighting should be affected by it followed as a natural sequence. There was another element which had operated very adversely to the progress of electric lighting in this country, and that was the unfortunate legislation which took place in 1882. As the chairman of another company the other day referred very fully to the steps now being taken to bring about a better condition of things, he did not think it was necessary for him to say more than that they had very good reason to hope that something would be done during the present session of Parliament—although, he was sorry to say, legislative efforts had been frustrated to a great extent by a condition of circumstances which he trusted might not be of long duration. He thought they might congratulate themselves that the Bill introduced by the noble lord, the chairman of the Brush Company, had passed the second reading. He might be allowed to say, as he had given notice of a Bill in the Commons, and did so before the noble lord introduced his measure, that his Bill was by no means antagonistic to that introduced by the noble lord. He had been in communication with him and they had arrived at the conclusion that, while he thought the Bill of the noble lord was far from satisfactory—in fact, most inadequate to meet what was required to remove the restrictions at present existing—yet he had agreed to introduce his Bill into the Commons, and on the same lines as that of Lord Thurlow. At all events, the effects of legislation would be to a large extent to remove the circumscribed sphere in which electric lighting had been up till now, and must necessarily be until corporations and public bodies saw their way to adopt the electric light, or allowed contractors into the various areas as suppliers, subject to equitable and remunerative terms and conditions. They had been labouring under great disadvantages, but he had been endeavouring, by communications with corporations and local bodies, to represent the advantages of those bodies taking up electric lighting themselves under the Act, and, of course, recommending the Maxim-Weston as the best and most suitable, not only for public lighting, but also for domestic purposes. There was one unfortunate condition of affairs, which the shareholders of this company must be conversant with—namely, the disastrous litigation which had been going on during the past year. But he was pleased to say that the Maxim-Weston had taken no active part in that litigation, neither as plaintiffs nor defendants. They had not been attacked, nor were they in the habit of attacking; although, should they be at any time attacked, they would, he believed, be able to defend their rights. Their patents had been recognised *in toto* in the United States. He thought they could prove exactly what their patents were; and, at the same time, he might say, his feeling was distinctly favourable so far to the Edison contention. That company, like themselves, had expended a large sum in patents, and he failed to see why their patents should not be maintained, perhaps not to the extent of their claims, but their district patents ought to be maintained. He thought it was clearly in the interest of this company to take up that position, and while not occupying any active part in their prosecution, they had refrained from taking any hostile position, although pressed frequently by the defendants in the recent suit. Electric lighting had made more rapid strides during the last three years than perhaps any branch of practical science; but, at the same time, it must be admitted that it was still more or less in its infancy, and as such it was essential that this company should keep in the van in connection with all their patents, which necessitated a continuous outlay. The amount added to patents account in connection with costs incurred in material consumed and labour expended in experiments, had been as nearly as they could estimate the actual outlay. They had not charged a single fraction for new patents or improvements on existing patents beyond the actual outlay, and while he had no wish to draw invidious comparisons between their company and others, he thought he was right in stating that the improvements for new patents or patents acquired in connection with another company for the past year amounted to 14,000. Now, during the year the amount their own company had added had been under £1,400. During the year they had designed and carried to satisfactory completion a new arc lamp—which he considered, and which he thought most of the shareholders would consider, if they saw it, one of the handsomest and also one of the most efficient lamps on the market—as well as important improvements in their dynamos, electrical appliances, &c. But there was another important feature in connection with the output of electrical plant, and that was price. During the year he thought he was correct in saying that the turn-out of plant—that was, plant actually sold—amounted to double the quantity sold last year, while the value obtained for the plant had not been more than 20 to 25 per cent. as compared with last year. They had had to refuse a great deal of business which they considered of a risky character, and on which the profit was small. They had endeavoured to meet large customers throughout the country in price, and he thought he might safely say that this company had now something like 100 firms or companies as customers, who were the most distinguished in the various departments of business in which they were engaged in this country and the colonies. They had also, through the American Company, been in communication with several countries in Europe and had appointed important agents in some of these. They had been fortunate enough to secure Government contracts,

and he was happy to say that, although a large number of the orders since received were not included in the accounts of the past year, they could now look upon as closed, business in the aggregate amounting to nearly the full quantity of business they were enabled to carry through last year. They should have liked to include those in the year under revenue, so as to show a better result, and he fully expected, when he last had the honour of addressing them, that the directors would have been able to pay the same dividend as last year. But, in connection with important contracts, long delays often took place, and he might mention that in the case of one large Government contract negotiations had lasted over a period of 18 months, so it was difficult in doing a large business to bring it within a given year. With regard to the concessions, this company formed a subsidiary company in Lancashire, which, however, was unsuccessful in its operations, and they acquired the right from Lancashire at a nominal sum, taking back the plant and concession and so forth. That increased the patents for the present year by £1,900, which ought to have been written back last year; but he was happy to say that during the year under review they had done between £4,000 and £5,000 of business in Lancashire, and, forestalling the probable passing of the amendment upon the Bill of 1882, they were now in negotiation throughout the country with corporations, local bodies and others which he had reason to hope would result in a large business. He might say as the result of trials and tests made in some of these places, that several other corporations with whom they had been in negotiation had intimated that they would do nothing whatever in the matter of electric lighting, until one or other of those places decided that their plan should be adopted. It was needless for him to say that in the event of one large corporation taking up their system, it would represent a sum at least three times in excess of the business they had hitherto been able to do in any one year He thought they had so far shown the superiority of their patents. They possessed now complete arc and incandescent systems. They had two incandescent dynamos; they had one arc dynamo and an improved dynamo; they had two arc lamps—a new one designed by themselves during the past year. They were constantly receiving new patents from America, but they were not dependent altogether on America, because they had a complete experimental staff here, and they were doing everything to make themselves independent of the American company. Their object in doing so, which necessitated an outlay, was simply this, that while the American company had met them most handsomely in the matter of price, and they got the plant from it at a price which constituted a small percentage on the manufactured cost, still it was undeniable that America was far behind in the matter of price. He need hardly point out, as a free-trader, that that was due to protection, wages and material being proportionately higher than here, and he thought he might safely say America was at a disadvantage compared with this country of 30 per cent. all round in electrical plant. Of course, if they could manufacture plant here at an advantage of 30 per cent., they would occupy a much more favourable position, but, at the same time, he considered it desirable to maintain their friendly relationship with America, because there was a large staff there. There was now £5,000,000 sterling invested in the States in the parent and sub-companies, and they were constantly experimenting and improving, so that their improvements were of vital importance, and it was, therefore, the object of this company to maintain, as far as they could, their connection with the American Company, as long as it was not detrimental in the matter of price. He believed that in Lancashire, Cheshire, and North Wales, they would do five times the amount of business during the current year provided the new Bill became law, and set them free from the suicidal legislation of 1882. The company had now a number of influential representatives throughout the country; but they had found the same difficulty as other companies in getting good reliable men. They did not as a rule give a salary, but a commission only, and in nearly every case they had obtained agents on these terms. The Chairman, referring to the 58,000 new shares which had been issued during the year to the shareholders, said this was done on a recommendation made at the last meeting; but he found, to his regret, that the bulk of the shares had fallen into the hands of people who put them on the market, thus depreciating the holdings of other shareholders. He was a large shareholder himself, and when the company was struggling and the other shareholders would subscribe almost nothing, he took up 16,000 or 17,000 shares, so that the present position of the company was really built up on the capital he had found. As to this last issue of shares, he considered it would have been more equitable to the general body of shareholders if the shares had been placed on the market, which he could have done at a premium of £4,000, which would have enabled the payment of a dividend of 10 per cent., instead of that advantage going to a very few persons. He had received a letter from a shareholder suggesting that, as the dividend to be paid was only 5 per cent., the directors should give up half their fees. He was obliged to the gentleman for the suggestion, but during the five years he had been a director of the company he had not drawn £100 in fees. He simply drew his remuneration as taking the entire control of the company, and if it were the wish of the shareholders, he was willing to give up that position. With regard to the new factory, they had secured a long lease, the rental being £180. High officials connected with the Admiralty had inspected the premises with a view to the execution of Government contracts by the company, and they had reported favourably on the condition of the works. With respect to the complete installations supplied by the company, they had in each case given full satisfaction. They had given up mixed installations. They did not want to interfere with any other company, and they did not wish to be interfered with, and they were prepared to fight if necessary. Therefore they favoured the Edison Company as far as the maintenance of their right was concerned. The chairman, having gone through the accounts seriatim, imformed the shareholders that they might see the new arc lamp at the premises of Messrs. Gask and Co., Limited, Oxford Street, where 22 lamps, and also some new Weston incandescent lamps, had been fitted up. He concluded by moving the adoption of the report and accounts.

Mr. Louis Swabey seconded the resolution.

Mr. Jackson expressed his satisfaction with the exhaustive speech of the chairman, and said he was astonished that any shareholder could have made such a suggestion as that the directors should give up half their fees because they only paid a 5 per cent. dividend. He considered for a young company, placed under circumstances of extreme difficulty as this had been, its present position was a very satisfactory one. At the same time, he thought it desirable that the audit should be more comprehensive.

The Chairman, in replying, said with regard to the audit, he could say that no more exhaustive audit ever was made than that by Mr. Dever—every item had been checked by him. When he (the chairman) took up the control of this company, the assets would not have fetched £5,000. They had added £25,000 to the capital, making £30,000, and during the five years they had debited themselves £40,000 or £50,000 more than the thing would have fetched when the present directors took office. With regard to the system of keeping the accounts in this company, he had nothing whatever to do with the book-keeping of the company. The board had engaged a professional accountant to see to that, so that in reality the accounts were checked by two distinct professional men.

A Shareholder asked if this company's patents had been infringed.

The Chairman said there had been infringements over and over again in this country, but he had never thought it worth while to go to law as long as he could make profits from their own working.

Mr. Griffiths hoped that the board would be content with their present plant—that they would not purchase any new patents or make any expensive improvements. They were indebted to the chairman for his able management, and he thought a great deal of the success which had attended the company was due to him. The report and balance sheet showed a considerable improvement on those of previous years. He hoped they would go on in the same direction, and then instead of wanting to diminish the directors' fees, they would be willing to increase them.

The Chairman said he could hardly agree with Mr. Griffiths in the matter of the improvements, because one dynamo which had been improved now kept seventy lamps running, whereas it formerly only maintained thirty lamps. They had been enabled to raise their prices by doubling the electrical output of the machinery. He hoped the shareholders would not tie the hands of the directors as regarded carrying on improvements. They had now got a very able staff of experimental men, and they had a practical manager second to none. The noble lord, the chairman of the Brush Company, had prophesied a considerable increase of electrical business if his Bill became law. He, he believed, predicted an increase of 20 per cent. for the Brush Company; but if the Brush Company got an increase of 20 per cent., the Maxim-Weston, he believed, would get 30 per cent., because they had so far been in advance of the Brush Company, and were not likely, he hoped, to get behind in the future.

The resolution was put and carried unanimously.

The Chairman moved the declaration of a dividend at the rate of 5 per cent. per annum for the past year.

Mr. John Brown seconded, and the motion was carried.

The retiring directors, Mr. Hugh Watt and Mr. John Brown, and the auditor, Mr. Henry Dever, were re-elected, and a vote of thanks to the Chairman brought the meeting to a close.

Western and Brazilian Telegraph Company, Limited.

THE fourteenth ordinary general meeting of the shareholders of this company was held on Tuesday, at Winchester House, Old Broad Street, Mr. C. W. Earle presiding.

Mr. R. M. Cunningham, the secretary, having read the notice convening the meeting,

The Chairman, in moving the adoption of the report, said the important mission undertaken by Sir H. D. Wolff, the chairman of the company, was expected to terminate shortly, and the directors had not therefore thought it advisable to make any change in the chairmanship. To bring themselves in accord with other telegraph companies with whom they exchanged accounts, their accounts on the present occasion had been extended to include a period of 15 months, instead of the usual 12 months. For the purpose of facilitating comparisons, the account had been divided so as to show clearly what the receipts and expenditure for the 12 months had been, and also to show the results of the three months to the end of December. Respecting both the receipts and expenditure for the last three months embraced, it would not be wise to multiply by four with the view of arriving at an average of what the result for the year would be, as the receipts for the three months showed some abnormal increase; while, as regarded the expenditure, payments had been made the

effect of which would extend over six months, or even a year. He thought they would admit that the whole result of the 15 months' working was very satisfactory in comparison with anything they had yet been able to show. Although there had been a decrease in the 12 months' receipts compared with those of the preceding year, it must be remembered that 1885 showed an improvement over 1884 of £21,000. Moreover, last May the Brazilian Government made a further reduction in their rates, and the company had to follow that example, as they were competing with the Government land lines. He stated that the volume of traffic had continued to increase. Comparing the working of January and February this year with that of the same months of last year an increase was shown in the traffic of 45¼ per cent., and in money of 23 per cent. The negotiations with the Brazilian Government—a matter which excited some interest last year—had not been proceeded with, and he might say that they were in complete abeyance. They had not been in communication with the Government themselves, the proposals for acquiring the company's property having been made to them by other parties. The company was now in a much stronger position to deal with any parties who desired to buy up their undertaking, seeing that the condition of the cables had been so greatly improved, and that the revenue had shown such a large increase.

Major Wood seconded the motion.

Mr. Guesdon urged the sale of the property to the Brazilian Government. He thought that more information should be given in the accounts, that half yearly meetings should be held, and that the directors—in view of the decision on the subject by Mr. Justice Kay—should discontinue issuing proxies. Mr. Guesdon further called attention to clause 7 and the latter part of clause 26 of the Articles of Association. Clause 7 was as follows: "Any director or officer, either individually or as a member of a partnership, company, or corporation, may be interested in any operation, undertaking, or business undertaken or assisted by the company, or in which the company is interested, and no director or officer shall be disqualified to act by reason of his being so interested; and as a director he may vote on all matters relating to any such operation, undertaking, or business in which he is interested as aforesaid, notwithstanding his being so interested." Continuing, Mr. Guesdon said that such an arrangement as that would not be permitted under the Government. The latter part of clause 26 was as follows:—"Notwithstanding any rule of law or equity to the contrary, no director shall vacate his office by reason of his being concerned in or participating in the profits of any contract with the company, and no contract or arrangement entered into on behalf of the company with any director shall be avoided, nor shall any director be liable to account to the company for any profit realised by him from any contract or arrangement by reason only of his being a director, or by the fiduciary relation thereby established." Such clauses as those ought not to exist in any company's Articles of Association, and he regarded them as a disgrace to joint-stock enterprise.

Other speakers advocated the holding of half-yearly meetings, and objected to the issue of proxies.

Major Cotton expressed his conviction that the directors would remove the clauses in question if it were the general wish of the shareholders. Mr. Guesdon ought to have pointed out that the articles were dated 1873, and that the present directors had had nothing to do with framing them.

The Chairman, replying upon the discussion, said that the directors intended to continue issuing proxies, but they had been sent out at the expense of the board. They had not been in direct negotiation with the Brazilian Government, and what Sir H. D. Wolff had stated on the matter occurred three years ago. They could not go to that Government and implore them to buy the property, but the board were anxions to sell it, and they had stated their terms to the parties who had approached them. By the articles of association only one general meeting a year was to be held, but the directors would consider what had been said on the subject. Mr. Weise, the auditor to the company, thought their renewal fund ample. The articles of association would permit them to pay quarterly dividends.

The report was then adopted, and a dividend of 13s. a share was declared, or at the rate of £3 9s. 4d. per cent. per annum for the 15 months, giving to the preferred ordinary shares 5 per cent. for the 15 months, and 3s. 7½d. per share on account of arrears for the year ended September 30, 1884.

The retiring directors, Sir H. D. Wolff and Mr. Earle, were re-elected, as also was the auditor, Mr. Weise.

A vote of thanks to the chairman, directors, and staff terminated the meeting.

TRAFFIC RECEIPTS.

The West India and Panama Telegraph Company, Limited. The estimated receipts for the half-month ended the 28th February are £2,921, as compared with £2,490 in the corresponding period of 1886. The November receipts, estimated at £4,347, realised £4,485.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending March 4th were £2,947 after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited.

The Great Northern Telegraph Company, Limited. The receipts for February, 1887, were £19,200; 1st January to 28th February, 1887, £39,000; in the corresponding months, 1886, £38,680; and of 1885, £41,200.

The West Coast of America Telegraph Company, Limited. The gross earnings for the month ending 28th February were £4,625.

The Brazilian Submarine Telegraph Company, Limited. The traffic receipts for the week ending March 4th amounted to £3,496.

PROCEEDINGS OF SOCIETIES.

The Society of Telegraph-Engineers and Electricians.

At the close of the discussion at the ordinary general meeting on February 24th, upon his paper on "Telephonic Investigations,"

Prof. Silvanus P. Thompson, in reply, said: It is the custom in another place to deal tenderly with the maiden effort of a new member. I can hardly say that this is the first time of my rising to speak before this society, but certainly my maiden effort at writing a paper to bring before it has received a large amount of attention from my friends, and I cannot complain on that score. But when I rise to answer the criticisms that have been made my difficulty is to find something that has not been answered already, because it seems to me that nearly all the speakers who have taken part in the discussion have either answered one another, or have touched upon the matter in such a way as to leave me scant room for reply. I propose to say something, however, in reply to every speaker, and I will deal with them in the reverse order to that in which they have spoken, last first. Prof. Fleming has certainly not emphasised the importance of the induction coil or transformer more than I myself would wish to do. I did not in my paper describe all that I had done in the way of constructing induction coils. One form that I had with me, but did not show, consisted of a secondary coil wound in two halves between which the primary coil was placed, the core being of large diameter and small lengths; that form worked extremely well, but it was rather awkward to build. I considered, also, how to make the mutual induction a maximum without increasing the self-induction. If you have a primary coil with self-induction, L, and a secondary coil with self-induction, l, then the square root of the product will be equal to the mutual induction between those two coils if the primary and the secondary circuits could be brought to absolute coincidence; but that is a course practically impossible, and therefore the coefficient of mutual induction is always less than the square root of that product. As was pointed out by Prof. Ayrton, a closed magnetic circuit is of no value *per se* in a transformer unless the current is reversed. That is exactly what I did in arranging it with a double primary worked differentially. My arrangement was an iron ring similar to the first transformer ever made, and which is represented in marble in the hand of the statue of Faraday which is in the Royal Institution—the type of all transformers, having a closed magnetic circuit and two coils.

As to the sonorous discharges referred to by Mr. Yeatman, I will only point out that among the numerous kinds of receivers that are classified in my table there appears this very one under the electrostatic head as "air sound" in a condenser. A brass ball electrostatically charged to varying degrees of potential gives off sounds on account of the varying electrical pressure on the air outside it. The action is similar to that which takes place at the surface of an electrified soap bubble which alters in size in consequence of the pressure due to the electric charge upon it.

I was quite prepared to hear Prof. Ayrton describe the microphonic effect as a sort of arc, but I am not sure that that helps us much, seeing that our present knowledge of the voltaic arc is so limited on account of the difficulty of examining it. I would rather say that the arc is a sort of microphonic contact if there is so much similarity between the two. No doubt there are molecular bombardments in both, but I think they differ in kind. I would refer you to the researches of Stoney, Barrett and others, which prove that a drop of liquid between two metal plates is separated from them on account of the bombardment of particles which go up faster than they come down, because the bottom surface is hotter than the top surface. Mr. Stroh's beautiful experiments with the microscope showed that particles were flying quicker in one direction than in the other, giving rise thereby to a stress or force tending to mutual repulsion: I think that in this lies the outline of a future theory of the microphone. Prof. Ayrton suggested an experiment with the arc to show whether it would start when the carbons were apart from one another, and without touching. I tried such an experiment in that direction as far back as 1878, and can say that it will not; but probably if I could have obtained a sufficiently high temperature the arc might have started. The arc seems to require a path finding for it, and it is the easiest thing in the world to start an arc by the spark from an ordinary induction coil. Going back to Count Du Moncel's experiment, referred to by Prof. Ayrton, as to whether transformers work better in closed circuits: I would point out that there is an early contribution to this question in a volume of Silliman's Journal about 10 years ago, by Prof. Trowbridge, who described a double induction coil so arranged that the end of one core was a north and the adjacent end of the other a south pole, there being also two pieces of tin plate opposite their ends, so producing an excellent induction coil. Had he only listened to those tin plates, he would have heard a good deal going on, and would have found an admirable telephone receiver.

It is quite true as General Webber has said in regard to the membrane form of receiver; a great many of that form exist up and down the country. It is of the ordinary form, a membrane stretched over the receiver frame like the cover on a jam-pot, with a little piece of iron in the middle. That form works well, and has been adopted, as it appears to be less open than some other kinds of receiver to cavil in certain directions. It is easily so arranged that damp does not affect it materially.

Respecting the question of the stress on the receiving diaphragm, the explanation given by Prof. Forbes was practically a repetition of that recently advanced by Mr. Oliver Heaviside, and is no doubt one answer to my statement that, as regards the question of the necessity of initial attraction, there was more to be taken

into account than had been done by M. Giltay, who found that why an initial pull was required was to obviate double vibrations. Now it is not a question altogether of attraction or whether the vibration is greatest when the magnetism is great; it is a question of the variation of the magnetism that comes in in this particular case. I have tried various experiments in this matter, and among them experimented on a small piece of iron, surrounded with two coils, primary and secondary, and with a third over the outside, into which were led currents from a few accumulators through a variable resistance. The object was to see whether greater effect was obtained from small intermittent currents when the core was more highly magnetised; and, though I hardly believed it at first, I found it to be so. I extended the experiment until the coil became very hot and must have been well up to 15,000 or 16,000 magnetic lines to the square centimetre. Those results have a great deal to do with what Prof. Forbes said had nothing to do with the case. I shall be very pleased to see Lord Rayleigh's paper which is to be published in March. I was much interested in Prof. Forbes's new red-hot transmitter, which is one more to be added to the long list I have already brought together. Prof. Hughes objected to my including in that list forms of instrument that were mere scientific curiosities, not of practical importance; but my object was not to distinguish between those and instruments of practical value, for in dealing with abstract science it matters not of which kind they are. Prof. Forbes has classified them into those which have legal diaphragms and those which have not. Prof. Hughes has said that the air itself is a legal diaphragm! It has been said that the human body is a legal diaphragm! Certainly the human body is a tube whether it is a diaphragm or not.

Now I come to Mr. Stroh, and I congratulate the society very much that my paper has been the means of drawing out Mr. Stroh into giving us that most beautiful account of his further researches upon the intimate phenomena of the microphone. You may call my description of what I thought happened at the microphonic contact, poetry, but Mr. Stroh's prose far outdoes my poetry. I have no poetry that can describe such extremely beautiful phenomena as those he described, and I am looking forward to time for an opportunity of trying those beautiful effects. I know from experiments made long ago that a very nice transmitter can be made of two metal points with a drop of paraffin oil between them, but I did not know how many beautiful things were to be seen in that drop of oil by the aid of a microscope. It was one of the most interesting things I have listened to, to hear how the little particles moved about in circulating currents at the point of contact, with the peculiar unstable state, the transfer of particles being quicker one way than the other; and how when the carbons were pressed together the contact took up a tone of its own and sang. No doubt we all, as I did, fully appreciated the importance of the relation between the action thus described and the phenomena of electric conduction at the points of contact. The instability observed by Mr. Stroh reminded me of that curious little thing called "Trevelyan's rocker," which is a grooved piece of brass heated and poised while hot on a lead base, and which wobbles about or vibrates until it sings. Prof. Tyndall made researches on that phenomenon—they are referred to in his books on sound and on heat—and said that the effect was due to the rapid expansion of the lead causing the rocker to be continually hitched over. I do not agree with that explanation, but think that what really happens is that a sort of polarised layer of flying molecules is formed underneath, and that something very like microphonic action is set up. As a proof of that, if the rocker is put in a circuit with a low resistance receiver and placed on a pine sound board its motion can be heard, which seems as though a thermo-electric current is more or less set up. I look upon it as a microphone which works under rather peculiar conditions; it transmits badly and belongs to the scientific kind, and is not of those that are of practical value. Professor Hughes took me to task for saying that the arrangement of microphones should be in parallel, and said that for high resistance they should be in series, for low resistance in parallel, and grouped for intermediate as with batteries. I quite agree in that view: but we do not work practically with high resistance, and with an ordinary transformer in which the primary is of low resistance, I prefer the parallel arrangement. He also said that with my Valve telephone the tube itself vibrated and acted upon the ball. My answer to that is that you speak to the tube, the voice goes up the tube and beats against the bottom of the ball, by which I get all that I require without the tube vibrating. If you put on 100 feet of speaking tube the ball will act just as well. Is it the tube and not the air inside? (Professor Hughes: Certainly: the sound goes through the wood.) But tubes are not made of wood, and it makes no difference whether it is a spiral wire tube lined with felt, about as dead a thing for conveying sound as possible, or any other tube, the ball acts. Again, if the ball be placed in a leaden bed, slung on a hammock of India-rubber with the end of the tube three inches away and not touching it at all, the ball talks by the air beating upon it. I tried a bed of putty and all sorts of things to cut off vibrations and the experiments were quite satisfactory. If the tube be plugged with a firm plug of cotton wool, the difference between the pressure of the air on the ball when the tube so stopped as compared with when it is open is most marked and clearly proves whether it is the material of the tube which conveys the sound or the air inside it. I quite agree with Prof. Hughes that such materials as wood or metal convey sound something like 12, 14, or 16 times *quicker*, but I do not think that therefore necessarily they carry *more*. Suppose $\frac{1}{100}$th part of the sound is conveyed by the material and $\frac{99}{100}$ths by the air, which will affect the ball? Of course the larger portion, and I feel quite sure that the rapidity with which the sound goes through the metal has nothing to do with it.

Professor HUGHES: I may mention that the experiments about sound are due to Prof. Wheatstone with his rod of wood. As for lead, it is a remarkably good conductor.

Prof. THOMPSON (continuing): I am perfectly aware of Prof. Wheatstone's experiments, and I have spoken through a lead wire. I am very much indebted to Prof. Hughes for his statement that it is not the business of the designer of instruments to cure bad wires or to cure what appears to be inherent, viz., that wires must somewhere run near other wires, but by making the instruments powerful we can get rid of stray currents and useless mutual induction. Sir William Thomson followed the same course in his investigations upon cables, and he produced the siphon recorder, which, with its big field magnet and comparatively small and light armature, is very like a dynamo, and which is very similar to what I am describing, and lies in the direction in which I hope still further to go in the design of telephones.

Now I come to a gentleman who put a whole string of questions to me, Mr. Moynihan, and I rather judged from his manner of putting them that he did not write them himself, because he did not seem to know what he was talking about. As to improvements since 1878-1885, I must refer him to what has been done by Mr. Langdon Davies with his phonopore and his open circuit telephone, and by Graham Bell, Chichester Bell, and Sumner Tainter, as also by Rosebrugh and by Elsasser, all of whom have done an immense amount of work since 1885. As to the number of instruments and the length of lines upon which they worked, I must refer Mr. Moynihan to the Secretary of the New Telephone Company for such information. Mr. Moynihan mentioned, truly; that Edison used thermo-piles for transmitters, but Edison did not use them as I did, as they were operated by the beating against their surfaces of the neighbouring diaphragms; and although Edison said his form worked, I could never get one of them to. As to how many instruments of various forms I have invented during the last eight years, I can only inform Mr. Moynihan that it does not take long to devise a new form when experimenting; I should think I devised a hundred when experimenting with what ultimately became the Valve telephone; and when one has several assistants all at work in the same direction it is easy to get several hundreds in a very few months. In regard to the break in the Blake transmitter causing a spark and blurring sound, Mr. Moynihan could not have read slip 8 of my paper, or he would have seen that I distinctly state that in my instrument no spark occurs on account of the double differentially-wound coil in the transformer. I further said that the Blake also works splendidly when provided with the double coil. Mr. Moynihan wanted to know what an induction plug was. If he had read slip 8 of my paper he would have seen that I use an electro-magnet as an induction plug. I thought an electro-magnet was a plain and well understood term, and I do not know whether Mr. Moynihan wished to score a point for my having invented a new term when I used the word electro-magnet. Mr. Moynihan surely cannot be ignorant of the fact that an electro-magnet is in a sense opaque to the passage of induction currents. Varley took out a patent in 1870 for a sort of telephone and telegraph, in which he used for the same purpose an electro-magnet, which he called an "echocyme," because it was opaque to the current; Van Rysselberghe used the same and called it a "separator." I do not quarrel with them for using those terms; but I said that I used the electro-magnet as an induction plug, which description I consider equally applicable, and, in my opinion, preferable.

Now I come to Mr. Preece. I am told that Mr. Preece has been detained by important engagements and cannot be present this evening, but I do not doubt that he wishes me to answer his remarks just as if he were here. Well, it is really extraordinary that I have survived the terrible criticism which my paper received at the hands of Mr. Preece, but the truth is that we have, as he told you, fought before, and he knew beforehand that I should return the attack; he knew it and expects it. We all know how perfectly sure, in fact cocksure, Mr. Preece is when he forms opinions or makes statements. He was cocksure that the early forms of telephones were only toys; he went to America cocksure that he would in a quarter of an hour expose Graham Bell. He was cocksure that my theory of the telephone was wrong. Now it may be admirable to say so but it is not scientific. There is not much for me to answer, because when Mr. Preece spoke the second time he executed two strategic manœuvres; in the first place he buttered, and in the second place he hedged. Well, I do not mind either the butter or the hedging. Mr. Preece now says,* "The suggestion made by Professor S. Thompson had been adopted ever since the early days of telephony, but it was communicated in a paper read by him (Mr. Preece) before the British Association in 1877. It was the basis of all the work and discoveries of Edison, and had been used by Mr. Fletcher on the London and North-Western Railway for short circuits between signal cabins for overcoming the disturbance due to induction from neighbouring wires. . . . He agreed that if it were possible to diminish the sensitiveness of telephone receivers to any large extent it should be done, but it was only possible to a very small extent, and then the limit of the human ear was soon reached." Well, if you make the transmitter sufficiently powerful there is no difficulty with the human ear. I think Mr. Preece is decidedly in that opinion coming round to my point. Further in 1877, for I have looked up the report, Mr. Preece says, "the

* ELECTRICAL REVIEW, Feb. 11th, 1887.

transmitter currents are too weak, and Mr. Edison of New York has endeavoured to remedy those defects in Bell's (transmitter) by introducing a transmitter which is operated on by a battery current." . . . . "Starting from Reis's transmitter, he simply substitutes for the platinum point a small cylinder of plumbago." . . . . "The interference of working wires will seriously retard the employment of this apparatus; but there is no doubt that scientific enquiry and patient skill will rapidly eliminate all practical defects." What I said was that the proper thing was to make the transmitters more powerful and drown out the induction sounds, and there is a great difference between that and what Mr. Preece said in 1877. As to my theory, if I may call it so, of the microphone; on the first occasion Mr. Preece described it as mere poetry, and on the second occasion he described it as being the same as his own theory of 1882. I have looked up the volume of 1882 and this is what I read as having been said by Mr. Preece.* "In 1877, at Plymouth, I had the pleasure of showing in actual operation the finally developed instrument now known as the Bell telephone. . . . The true action of the microphone is very little understood. . . . Carbon is the best material, because it is inoxidisable and infusible, because it is a poor conductor, and because it has the remarkable property of having its resistance lowered when it is heated—the reverse of metals. This observation is due to Mr. Shelford Bidwell." So I find that in January, 1877, Mr. Preece said that my theory was mere poetry; on February 10th, 1887, it was his own theory, and that when I look back to August 28th, 1882, I find he says it was Mr. Shelford Bidwell's theory, so I do not know really which I have got to answer. I can only conclude that they are all three wrong; that my description was not poetry, that it is not Mr. Preece's theory, and that it is not Mr. Shelford Bidwell's. I find that Mr. Shelford Bidwell stated that he had discovered, what was pretty well known before, that the substance known to electricians as carbon changed its specific resistance when heated, but, unlike metal, which increased, carbon decreased in resistance, and he concluded from that that it had something to do with the microphone. It is rather a lame conclusion, but that is what he came to. I have pointed out to you that what goes on at the contacts has absolutely nothing whatever to do with the specific conductivity of the material. You can make a good transmitter out of gold, platinum, or hard carbon, or you can get bad conductors which do not work so well; it is a question of surface contact, not of what is a good or a bad conductor. My account of the intervention of heat in the molecular phenomena at the contacts is totally independent of anything that heat may or may not do to the conductivity of the materials. I believe my theory to be new, and to be true so far as it goes.

Mr. Preece says that there is a static retardation depending on the capacity and resistance of the line and independent of self induction and mutual induction, and quotes Sir W. Thomson's law that the time retardation is proportional to the square of the length of the cable. That is a deduction from calculation based upon the supposition that there is a single sudden disturbance, that the potential is suddenly raised from some high value at the sending end, and you are to see what happens miles away along the cable. Now that is not what happens in transmitting microphone sounds, where you have something much more like a harmonic variation, and if you take a harmonic variation you will find—taking Mr. Preece's own ground that the only things to be considered are capacity and resistance—that the mathematical calculation which I have prepared does not come out like Sir William Thomson's, but that the law for this case is that the reduction of amplitude is simply proportional to the length. It is quite true that the number of currents that pass through a line does not depend upon the electromotive force, but by additional force those that do pass may become less attenuated; and if my mathematics are followed out it will be found that the current at the far end is proportional to the amplitude of harmonic variation put in at the sending end. Mr. Preece was cocksure that the whole of the difficulties I have mentioned were imaginary, and that I have been fighting a myth. When he said that, I wondered what sort of instruments those were that never buzzed and never required adjusting. Even were they as perfect as possible, I respectfully beg to think there is still room for improvement in instruments. But what concerned Mr. Preece most was what he was pleased to call my perversion of history. That is rather an ugly charge, and might demand serious attention on my part if I did not know that it was only Mr. Preeece's way of saying that my version differed from his version of history. According to him, I was both unjust and ungenerous in daring to name Reis, Varley, and Wray in the same line as Bell and Edison; that I was ungenerous in comparing Bell, Edison, and Hughes with men who, according to Mr. Preece's version of history, only played with a musical toy. He said that before Sir William Thomson brought back from America Bell's telephones in 1876 nobody in this room had seen or heard of the possibility of transmitting speech electrically. Nevertheless, he must be aware that in 1861 Reis set out with the object of transmitting speech, and that the transmission of music was an afterthought. If he doubts it, let him go to the British Museum, where it is stated in black and white that vowels and consonants were mentioned, and that speech was intended to be transmitted. How far he succeeded is another question, but his object was to transmit speech. Yeates, in Dublin, as Mr. Preece knows, had done the same; and I myself, a whole year before Bell was heard of, had been shown a Reis instrument, and was told that it was an instrument by which you could talk for a distance by a wire. I proved it by experiment with a steel pin making contact against a flattened wire moved by a parchment membrane stretched over a jam pot. I say it is untrue to say that Reis's and Yeates' instruments were musical toys. Would it be just to Gramme to refer to his early dynamos as toy motors? No; he was inventing a dynamo, and it turned out to be useful as a motor afterwards; it was an afterthought, as was Reis's telephone, which was intended to be used for speech. Mr. Preece was particularly angry about the Brothers Wray, and said I had no right to use their names. Well, they brought out a really beautiful instrument as receiver: two electro-magnets on the top of a sounding-board acting upon one another; if they had taken a polarised relay and tied a string to it I do not think there would have been much invention in that, but they invented a new instrument for a new purpose, and I feel that I am justified in naming them as worthy of honour among the inventors of receivers; and as they invented a receiver which did that which no previous one would do so well, why should they not receive credit for what they did? As to Reis and Varley being mentioned in the same line as Bell and Edison. If Bell had lived 15 years before Reis, and if Bell had worked on for years, neglected, unknown, despised and rejected by all telegraph engineers of his time, who were cocksure that he was running after a myth, and then after all that he had gone to his grave, and if then two years afterwards it had been found that some one else had got the credit of the whole thing, I think that then people might have felt it unjust to mention Reis in the same breath. But it was the reverse; it was Reis went to his grave, despised and rejected, and was denied the credit. If I have been unjust to anyone it is to Reis, by coupling other names with his. As to the exquisite invention brought out by Graham Bell in 1876, when he showed that you could take an instrument like a polarised relay and make it talk to a similar one at the other end of the line, that was a subsequent and a very beautiful discovery. Nothing shall ever cause me to detract from the merit of this discovery of Bell: only he was not the first, and his invention has almost ceased to be used for transmitting speech. If I wanted any justification for naming in one line Reis, Varley, Gray, and Graham Bell, I have it here in a blue book or specification, dated 1st June, 1878. "This invention relates to improvements in telephones. . . . . In Reiss's, Gray's, Varley's, Bell's, and other known forms of telephone, these sonorous vibrations are reproduced directly by the action of electricity, and are reinforced by simple sounding boards or resonators. Now according to this invention the vibrations produced in the receiving instrument are transferred from their source to fixed or stretched membranes or discs in such a way as to increase the quantity of air thrown into sonorous vibration." "The receiving instrument will consist of a polarised relay, whose armature, vibrating in unison with the original source of sound, will, by its connection through a wire with a drumhead similar to that of the toy telephone, reproduce the transmitted sounds, whether articulate or otherwise." Specification of patent No. 2,202 of 1878, page 2. Patentee, W. H. Preece. Again I was accused by Mr. Preece of another perversion of history in regard to the invention of Rysselberghe when I said that "the much-applauded methods of Van Rysselberghe for the perfection of long-distance telephony are a mere commercial extension of the researches of Black and Rosebrugh in 1878—9," and he said that Rysselberghe had been roughly handled by me because his object was not to obtain long-distance telephony but to work telephones on the ordinary telegraph lines. One should be sure of facts. I find that the specification of George Black and Abner Rosebrugh taken out on April 16th, 1879, says, page 1, line 9, "The object of this part of the invention being to enable telephones to be connected with the wire of any galvanic circuit without interfering with the action of said galvanic circuit." "The invention consists, secondly, in connecting two or more wires of a telegraph line running in the same direction and using them as a conductor, by which arrangement . . . . . the length of line on which a telephone can be used is very much increased." And on page 3, line 15, they add that thus they can use the wires that are being used for ordinary telegraphic purposes also. The details of the specification show that in 1879 they were even using exactly the same means as Van Rysselberghe did in 1882, namely, that they used condensers to block the telephone circuits against the telegraphic currents, and employed the inertia of the electro-magnets in the telegraph instruments to block those instruments against the telephone currents! And yet forsooth I am told that I have perverted history! It was not until 1882 when Rysselberghe came to the front and caused some excitement abroad and companies were talked of that Mr. Preece could see anything in it. Mr. Preece has referred to my use of the word "transformer," I do not always call an electro-magnet an electro-magnet but sometimes a relay, which is a useful word, when the electro-magnet serves a particular function: and why should I not call an induction coil a transformer? He also objected to the term "quasi-metallic," which he thought was the same as semi-conductor. I did not invent that term. I have always been accustomed to think of there being two kinds of conductivity, that metals conducted in one way without decomposition, and that liquids conducted in another way with decomposition; it is a question of the constitution of the substance, and quasi-conductivity is a commonplace name to those who know the facts, for these substances, not metals which conduct like metals. There is retort carbon which is a good conductor, and sulphide of copper, which Faraday pointed out as

* Journal of S. T. E., Vol. XI., p. 610-616.

being an excellent conductor. Then Mr. Preece pointed out that the essential part of the majority of the transmitters described by me was a microphone, and he insinuated that my instruments had been designed to avoid infringements of other patents. That was extraordinary to come from him. What does he want? Does he want an inventor to invent things that infringe, or not to endeavour to improve without infringing? I shall be next denounced for not having stolen Mr. Preece's watch. Thanks to Professor Hughes's generosity, I am as free to use a microphone, which was never patented, in my instruments as I am to use a binding screw, which also never was patented, or a speaking tube, though that once was. Surely Mr. Preece must have forgotten his brief when accusing me of taking care not to infringe anybody's patent. He talked rather wildly about a patent being a property and said it ought to be protected—what for, to make it an instrument for grabbing every invention that it did not cover? I do not think that will go down, and Mr. Preece will have to hedge on that too. If a man who is not the first inventor of telephones takes out a patent for one kind of telephone, are you going to stretch that patent so as to include everything of every kind in telephones, including those expressly excluded in the inventor's own disclaimers? Listen to what Mr. Preece said on this point in this room on March 23rd, 1882. "*If the power of conversation by the variation of electric currents is to be made a monopoly, then there must be something very rotten in our patent laws, and something that urgently requires reformation."

Mr. Preece referred to his talking by telephone for some 270 miles, from Hanwell to Nevin, as easily as he could from St. Paul's to Westminster, but who wants to speak from London to an obscure place in Wales? Such a case was not comparable with what is required in ordinary practice where the environment of neighbouring wires must of necessity exist. It will take a very long time after the encouragement I have received from all quarters, on the theory of the construction of the instrument, to persuade me that I am not on the right track when I say that you must take the wires as they are, and must make the instrument specially powerful to suit the case.

A ballot for new members took place, and the meeting adjourned.

CORRESPONDENCE.

Electric Tramways in America.

I have read with interest your description of the "Bentley-Knight system" (?) of electric tramways.

Amongst the details of design and construction as illustrated in your Journal, both in connection with the track and the collector, which I suppose Messrs. Bentley and Knight will claim to have worked out, I fail to see anything which is not illustrated or described in one or other of my numerous blue books.

In the B.-K. "system," as in the one laid in Philadelphia, not only the good points of my earlier work, but some of my errors, also, are copied, and I venture to predict that if the Fulton Street line is laid in strict accordance with the description and illustrations you give, it will, like the one in Philadelphia, prove a failure.

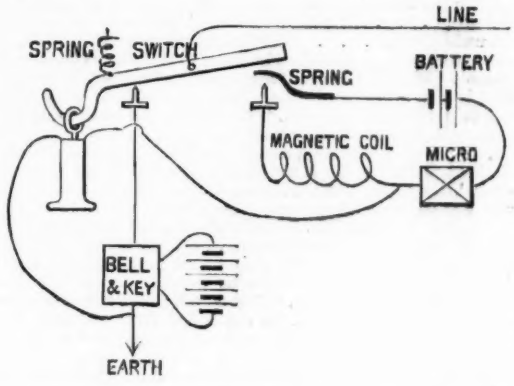
The sample track laid by me in Manchester in 1884 was pronounced by all who saw it, both engineers and electricians, as thoroughly satisfactory, but had I been of the same opinion and constructed the Blackpool line in a similar manner it would not have been a practical success. The Fulton Street design has in it a detail similar to the one that led me to abandon my Manchester section.

I notice from the Sprague correspondence that your paper is read on the other side, and therefore take this opportunity of stating that should the Fulton Street line be laid as shown, without my patents being recognised, I shall commence proceedings for infringement.

M. Holroyd Smith.

A Telephone Circuit.

The sketch represents the arrangement of telephone circuit I have proposed, which Mr. Preece spoke of at the Society of Telegraph-Engineers, and I understand promised that I should describe. I was, however, prevented from doing this, but hope you may be able to find room for it. The main difference from the ordinary method lies in the suppression of the secondary coil of the induction coil, and the connection of the line and return wires to the ends of the primary coil. The resistance of this coil is proportioned to that of the microphone and the number of cells used. I have obtained very good results with an ordinary Siemens or standard relay, the coils being connected in, divided with a modified Hunnings transmitter and 10 Leclanché cells, but with a microphone of the ordinary type less resistances and fewer cells are desirable. In any case, of course, the coil should have a large co-efficient of self-induction.



The station at the other end is connected up similarly, and it will be seen that when the switch is released the magnetic coil for incoming currents is shunted by the microphone and battery, and this constitutes its greatest advantage, although it was arrived at with a view to simplification of apparatus for the field. The signalling on short lines should be decidedly improved by the omission of the secondary coil, as there is a current on the line when the switches are released if the batteries be connected in series and not in opposition. Telephones without permanent magnets may be used, and for short lines they may with advantage be of lower resistance than usual.

P. Cardew.

The Broomhill Installation.

I will give the particulars, in reply to a note in your issue of this week, regarding the trouble caused by some of the wires breaking for no apparent reason.

The breakages occurred almost exclusively in the cellars, so I attribute damp to be partly the cause, although, in point of fact, the cellars are unusually dry, being heated by hot water pipes. The wires were Nos. 16 and 18, purchased from one of the first makers in England. The breakages did not occur at joints but at any point in the wire without preference; sometimes six places would go in less than two or three feet, so, clearly, it must have been due to the process of manufacture. At the parting points nothing could be noticed, beyond greenness from the presence of verdigris, and the insulation appeared perfect, no leakage being observable worth speaking of. The copper wire was tinned; possibly this may have assisted in the action.

It is needless to add that after repairing some 100 places in as many feet in length, it has all been replaced by new braided wire, about a year ago, and no trouble has arisen since this has been done.

David Salomons.

March 5th.

[The cause attributed by Sir David Salomons to account for the breaking of his conductors is, on his own showing, incorrect. We have little doubt ourselves but that the real reason could be traced to the *method* of tinning.—EDS. ELEC. REV.]

* "Journal of Society of Telegraph Engineers," Vol. XI., p. 146. 1882.